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Ideals

IT IS often said of a man in a deprecatory way, "He is a dreamer." And if he does nothing but dream, he is likely to be a disappointment to himself and to those who are interested in his progress.

The matter for regret is not that he is a dreamer, but that he has not the faculty, the capability of making his dreams come true.

Without its dreamers the world would be in a sorry way today.

Few human achievements have come by accident or have resulted from a spontaneous impulse. Sir Christopher Wren had to see his cathedral, to think and dream it out, before other people could see it in stone and timber.

But the man who does the world good, the man who helps mankind onward and upward, is the man who dreams dreams of helpfulness and usefulness and progress and improvement and then gets them materialized. It may be an invention that will lighten human toil or multiply the returns from human labor; it may be a means of eradicating a disease or mitigating human suffering; it may be a poem, song or story that will arouse human sympathy and influence many lives.

If one is to accomplish anything, one must have a purpose, an ideal and a plan.

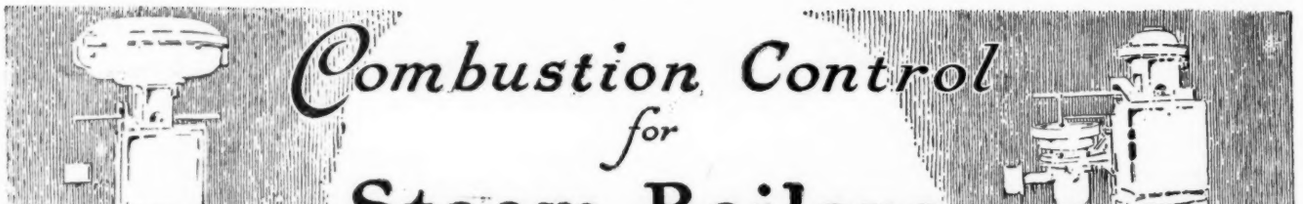
He may pitch his ideal too high. He may, with Emerson, hitch his wagon to a star, and be dubbed impractical, Utopian, "plowing the sea."

But no man, no society, no institution, no nation, no race can be better or greater than its ideals; and the people whose impulses are actuated and whose course is guided by lofty ideals, is bound to become great through the collective urge of those ideals and the common anxiety to see them effected.

An engineer whom I had known as an erecting man, and who got to be a consulting engineer and designer of some note, tried to tell me one day of the joy that he found in conceiving an idea, working out its possibilities, checking it up, putting it upon the drafting board, into the patterns, the castings, the finished machine, and then see it go and do the thing that it was designed and constructed to do. If Wren had sat with his eyes closed and his hands folded, lost in admiration of the structure that his mental eye beheld, the world would not know him nor St. Paul's.

Let us not be too hard on the dreamer — not the builder of castles in the air, but the man with ideas and ideals — for he is necessary to each step of progress that we make; but the real acclaim and the real reward will go to him who, seeing as in a dream, translates his vision into practical reality, of service to his fellow-man.

F. R. Low



Combustion Control for Steam Boilers

by

Charles H. Smoot*

A GREAT deal of attention at present is being devoted to the question of controlling combustion in boiler plants. A surprising increase in operating efficiency is available if the supply of air and fuel to a boiler be automatically controlled to give a uniform complete combustion without a large excess of air to waste sensible heat up the stack, on the one hand, and without incompletely burned gases, on the other hand. It has been found impractical to obtain this regulation by hand control throughout extended periods of operation. For a short run sufficient expert attention can be maintained on the boiler, but for every-day commercial operation few plants can afford the incidental expense, or even maintain skilled operators in efficient control of combustion.

It has appeared obvious to many that the only answer to this problem was not to regulate with men, but with a machine, and to do this successfully it is necessary to determine the essential elements entering into a satisfactorily regulated combustion, and when such elements have been determined, then assign a regulator to the performance of each of these elements. It does not require an extended study to ascertain that the most important elements for regulation are: "A," the supply of air; "B," the supply of fuel, and "C," the ratio of fuel to air supply.

Ratio Between Quantity of Air and Fuel

For a uniformly complete combustion, there must always remain a fixed ratio between the quantity of air and the quantity of fuel supplied, and in order that the plant load be maintained, it is further necessary that the supply of fuel and air be simultaneously increased or decreased as necessary to generate the steam required from the boiler.

To accomplish this regulation with mechanical apparatus is entirely feasible. It requires a regulator that will control the rate of coal supply, altering this rate as necessary to maintain the boiler-plant load, and a second regulator to control the air volume supplied to the boiler, also varying this as necessary to maintain the plant load. Both of these controllers must be maintained in synchronism by a master control, so that no matter what the rate of supply may be, they are functioning independently to maintain a fixed ratio between the supply of fuel and air.

The regulation of combustion is an old subject in other industries than power generation. In the iron blast furnace for years a careful control of combustion has been maintained as an essential, not only to economy, but to the actual production of pig iron. In the blast furnace air is supplied under pressure from a blower that is automatically regulated for constant volume.

The "A" regulator is either a constant-speed governor on a displacement compressor, which gives therefore a constant volume for a constant speed of rotation, or, in the case of a turbo-compressor, the air is regulated by some form of flow meter, which reacts on the turbine, changing its speed as necessary to maintain a constant air volume.

The "B" regulation of fuel supply to the furnace is maintained by manual control, in that a fixed amount of fuel in proportion to the air volume is charged into the furnace every hour.

In this way a fixed ratio of cubic feet of air per pound of coke (the "C" regulation) is maintained at all times.

When the furnace is working fast, the quantities of air and coke are both increased, and when it is working slowly, the quantity of both are reduced, but always the same ratio between them is maintained, and this regulation is identical to that required for the steam-boiler furnace.

Two Factors Controlling the Chemical Mixture Between Air and Fuel

In burning gas, similar precautions are taken in the various arts, and regulating apparatus is employed, which meters to the zone of combustion a supply of gas and air of suitable relative magnitudes to give an efficient combustion. Both "A" and "B" regulations are accomplished by means of pressure controllers which maintain a constant pressure for both air and gas flow through a metering nozzle before entering the zone of combustion. This constant-pressure regulation, with a fixed orifice having a definite resistance, results in constant volume regulation of air and gas. The "C" element, or relative proportions between air and gas, are also accomplished at the same time.

To control combustion for the purpose of generating steam, exactly similar methods may be used, and no new problems arise. The steam boiler has a somewhat different aspect, however, in that it is operated for heat and not chemical mixtures, and consequently less attention has been paid to its chemical characteristic than to its heat-producing characteristic, but to maintain high economy its chemical characteristic must be considered. In a steam boiler the heat produced is equivalent to the amount of steam generated, and the total quantity of heat must be varied accordingly.

The regulation of combustion in the mechanical stoker is not so obvious a proposition as the regulation of gas and powdered fuel. In the stoker there is always a mass of combustible in process of burning. To burn

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this fuel at maximum economy requires for each boiler and setting a definite flue-gas composition in which the CO_2 is high, the free oxygen low and the CO present, if at all, in only small traces.

There are two factors controlling the chemical mixture between air and fuel, the first of which is the temperature of the fuel bed, a high rate of combustion requiring a higher temperature of the fuel itself than a low rate of combustion. The temperature of the fuel will not change rapidly, and consequently a sudden reduction in the quantity of air produces, momentarily, over-combustion, with the formation of CO gas, while the reverse occurs on a sudden increase of quantity of air, resulting in the presence of free oxygen and a reduced percentage of CO_2. These conditions, however, are only momentary and follow a rapid increase or decrease in the amount of air passed through the fuel bed and result from the fact that coal at a given temperature tends to combine with air at a fixed rate. These considerations occur only during a change of condition, and by reducing as much as possible, consistent with plant operation, the rapidity of load changes on the fire, lessening of combustion economy from this source may be reduced to a negligible quantity. If time be allowed during a change in fire load, the temperature of the fuel changes with the rate of combustion so as to maintain efficient combustion.

The heat storage of the boilers themselves should be used for this purpose. By allowing moderate changes in steam pressure, the heat stored in the boiler, acts as a flywheel to equalize the load variations on the fire and reduces the necessity for rapid changes in rate of combustion, or "underblowing" and "overblowing."

The second and most important consideration in the combustion of coal on the mechanical stoker is the relation of fuel depth to average size of the burning lump of coal. In other words, the depth of the fire for a given degree of combustion should be in proportion to the average diameter of coal lump being burned. For example, the combustion of fine anthracite may be complete with 2-in. or 3-in. depth of fuel, while the combustion of large lumps requires a much greater thickness of fuel. The complete combustion of soft coal in underfeed stokers also varies with the size and character of coal. If the coal cokes into large chunks, it is necessary to have a thick bed of fuel, while if it remains in comparatively small individual lumps, without coking, a much thinner bed is suitable.

It is always necessary that the streams of air in their passage through the fuel bed be subdivided a sufficient number of times to encounter a succession of passages between lumps of burning coal in order that all the oxygen contained in the air may have an opportunity to combine with the incandescent coal or its surrounding atmosphere of CO gas. In a thin fire of large lumps, some of the air will pass through the larger openings and its oxygen will be given no opportunity of combining with the fuel. If a second layer of large lumps be superposed, this uncombined oxygen is given another opportunity of combining with fuel and for each additional layer an additional portion of the oxygen is consumed.

This explains the fundamental necessity for the thickness of the fuel bed being in proportion to the size of burning lumps. It is a recognized difficulty with mechanical stokers that it is hard to maintain efficient combustion when they are operating at a reduced output, the lower limit being frequently such that it is often more economical to bank a number of boilers on light loads, operating the other boilers at a fair rating. If it were possible to maintain efficient combustion with low ratings, this would be unnecessary and the wasteful condition of banked fires could be largely avoided by running all the boilers at a reduced rating. When the supply of fuel and air is regulated as outlined in the foregoing —first, in a fixed proportion to each other, and, second, with a total quantity in proportion to boiler load— the conditions going to make up efficicent combustion are in the main provided for.

WHAT takes place in the furnace of a boiler is not understood by many who are responsible for boiler operation. The author has presented a remarkably clear picture of what is going on when burning coal on a grate and the reasons for the difference in thickness of the fuel bed required, when burning different kinds of coals. With increasing costs of fuel, more power and cheaper power is the demand of industry. As a means of meeting this problem more careful attention is being given to the processes of combustion in the boiler room than ever before. The efficient control of combustion with widely varying loads is by no means a simple problem and is one on which a great deal of development work has been done during the last few years, and much progress has been made. However a great deal more will have to be done before a complete solution of the problem is obtained. Considering the intense interest in the subject a discussion of combustion control would undoubtedly be welcomed by many power-plant engineers, and *Power* invites this discussion.—Editor.

The thickness of the fire naturally takes the proper value for the combustion predicted by the rate of feed, the degree of mixture imposed on the boiler by the rate of feed obliging an increasing or decreasing thickness of fire until the point of equilibrium is reached, at which coal neither accumulates on the grate nor is burned from the grate, and is combined with the air, producing the flue-gas analysis imposed by the rate of feed.

The combustion in a boiler is a chemical process to which the ingredients of air and coal are supplied to produce heat and gas. All the coal and air fed to the furnace come out in the form of flue gas and ash. It is a continuous chemical process, in which maximum economy in fuel use depends on complete combustion. In other words, all the coal that is carried by the flue gas should be in the form of completely burned gas (CO_2 and H_2O) and there should be a minimum of excess air passing through to carry its quota of sensible heat up the stack. To maintain this condition, it is primarily necessary to feed, moment by moment, the proportion of coal and air to the fire which corresponds to the chemical mixture of flue gas that will produce maximum economy.

If the ingredients are supplied in proper proportion, it inevitably results in the gases leaving the furnace in the same proportion. This condition is entirely independent of the character of the fuel, whether coarse or

fine, or whether it readily forms coke or passes through the fire without agglomeration.

When the mixture is controlled by the initial supply of the coal and air, the thickness of the fuel bed accommodates itself to the requirements in a perfectly stable and dependable manner. If, for example, the fire is behaving in a proper manner, but a different grade of coal is supplied such that a greater thickness of fuel bed is necessary for its complete combustion, it is unnecessary to interfere with the fire, as the greater thickness of fuel bed inevitably results and for the following reason:

How Fuel Bed Accommodates Itself to Maintain a Stable Quality of Combustion

If the fuel be too thin for complete combustion, the air supply carries up the stack less than its proper share of fuel, with low CO_2 and free oxygen present. During such period coal is accumulating on the grate and increasing the thickness of the fuel bed until the amount of fuel carried up the stack by the air is again equal to the supply of fuel to the fire. If the fuel bed be too thick, the reverse occurs and the air carries up the stack a greater amount of fuel than is supplied by the stoker and reduces the fuel accumulated on the grate. These conditions of stability in flue-gas analysis and fuel-bed thickness are the direct and natural result of supplying to the fire a proper mixture initially.

The lower the boiler rating the more essential is the requirement in the supply of air and fuel for the reason that at a low rating the movement of fuel is slow, hours elapsing between the supply of fuel and its ultimate combustion. Consequently, if for a period the supply of fuel be in excess or deficient, the effect of such error appears in a poor fire condition some hours after the error was made, and so far as the stoker mechanism is concerned, the damage is irreparable and can be corrected only by hand. If, however, the supply of fuel and air be always controlled in proper mixture, there will never occur an excess or deficiency, and the fuel in its passage over the grate remains in a condition and of a thickness suitable for efficient combustion.

Regulation of Air Pressure Inadequate

To regulate the air pressure alone is totally inadequate. There is no direct relation between air pressure and air quantity passing through the fire, since the quantity of air is dependent on two factors, one of which is the resistance of the fuel bed. This latter varies with the grade of coal, the amount of clinker, etc., to such an extent that there is little or no relation between pressure of air supplied to the grates and quantity of air passing through the fuel bed.

This condition is well represented in a blast-furnace operation, in which the resistance of the mass of fuel and ore varies from time to time, so that with a constant air volume a pressure is required ranging from 10 lb. per sq.in. up to 30 lb. per sq.in., or a three to one variation in pressure, to send the same amount of air through the same furnace, the difference resulting entirely from a variation in the resistance of the bed of fuel to the passage of air.

In the underfeed stoker constant-pressure air regulation produces a condition of instability, and the fire, which has a low resistance because of being thin or because of holes developing in the mass of fuel, receives an excess air volume, whereas it should receive a reduced air volume. The increased air volume that results from a reduced thickness of fuel bed increases the rate of combustion and still further reduces the thickness of the fuel. On the other hand, if the resistance of the fire increases, the quantity of air is thereby reduced and the fire tends to still further increase an already excessive thickness.

Regulation of Air Volume Gives Stability

If, however, the supply of air be regulated for volume, regardless of pressure, the condition is one of complete stability. The thick fire receives the same volume of air, but at a greater pressure than the thin fire, and from the difference in fuel contents of the gases previously referred to, the thick fire is in time reduced to its proper thickness, corresponding to the mixture of air and fuel initially supplied, while the thin fire accumulates its thickness, increasing the percentage of fuel in the flue gas until the proper value of stability is reached.

Boiler-combustion control is by no means steam-pressure regulation. To regulate the supply of fuel and air and maintain a perfectly constant steam pressure produces inefficient fuel consumption for the following reason:

As already outlined, a fire at maximum economy will not respond rapidly to a big change in rate of combustion without momentarily operating at a reduced efficiency, consequently the changes in rate of combustion in the fire should be made as gradual as possible. If the fire be regulated for a constant steam pressure, all variations in the rate of steam generation are immediately reproduced in the fire rate of combustion. If, on the other hand, the steam pressure be allowed to vary with a reduction in pressure, on an increase of load, the heat storage capacity of the boiler itself acts as a flywheel and permits the fire to have a slower change in rate of combustion than occurs in the rate of steam generation.

Maintaining Fire in Good Condition

To maintain the fire in a good condition, with a rapidly changing load, it is necessary that there be a change of steam pressure to absorb the momentary demand and give time for the fire to change its rate of combustion without loss of efficiency.

As a direct result of the foregoing considerations, the greater the mass of incandescent fuel in the furnace the greater should be the change in the steam pressure permitted for a given rate of change of boiler output. A thin fuel bed will respond much more rapidly to an increase or decrease in rate of combustion than will a thick fuel bed, while powdered fuel responds still more rapidly. The less the mass of incandescent fuel in process of burning, the more rapidly it may change its rate of combustion. It is obvious that a regulation of mixture for gaseous, liquid and powdered fuel is essential for high economy in combustion. It is not so obvious, but it is of greater importance, to regulate combustion on the mechanical stoker.

Don't run with the ammonia compressor crosshead too loose. The stuffing box will leak if you do. Don't use more lubricating oil than necessary anywhere on or in the machine. The whole system is for heat transmission, and oil is a heat insulator. Don't pump oil into the compressor cylinder. Enough usually gets in there through the stuffing box. Don't neglect the oil traps; blow them down regularly—every two or three days.

Economic Value of Precooling Liquid Ammonia

ANYONE will agree that a feed-water heater pays in a steam plant. Apparently, the same agreement does not exist as to the advantage of a precooler in a refrigerating plant, although it works the same as the heater but in reverse order. Mr. Gunn goes into the method of finding out how and when a precooler will pay.

By T. M. GUNN

THERE are two advantages in precooling liquid ammonia before it goes to the expansion valve, either one of which may be the reason for its adoption. The first is a gain in the capacity of the plant, generally secured without increasing the horsepower input. The second is the fact that the colder the liquid passing through the expansion valve the less will be the initial formation of vapor at the valve (flashing), and so the coils will contain more liquid and can transfer heat more rapidly. This, in turn, increases the capacity of the coils and may raise the back pressure, decreasing the horsepower required to drive the compressor and increasing its capacity, in addition to the first gain mentioned.

The first of these advantages was discussed in *Power*, Feb. 13, where it was brought out that the increase in refrigerating effect is equal, in heat units, to the heat removed from the liquid ammonia in the precooler. Charts were given to assist in estimating the gain in capacity and the decrease in horsepower per ton.

It is convenient to remember that, as a rough approximation, each degree of precooling will increase the capacity of the plant by nearly ¼ per cent. This figure gives a general idea of the available gain, but it is better to make detail calculations where possible, for better accuracy.

Effect of Uncooled Ammonia.

The second advantage mentioned, which has to do with the behavior of ammonia in the expansion valve and refrigerating coils, is often regarded of enough importance to justify installing special liquid coolers or accumulators. The action in the expansion valve is quite similar to that taking place during the discharge of water from the lower try-cock of a steam boiler. If the try-cock is on a water column that stands out from the boiler enough so that it can cool off, the first water that comes out when the cock is opened will be a solid stream, like that coming from a water faucet. After a few seconds, when the cooled water has been drawn off, the very hot water in the boiler, at a temperature over 300 deg. F., begins to emerge, and the appearance of the jet is completely changed. At atmospheric pressure water boils at 212 deg. F. and cannot continue to be water at this pressure if there is enough heat present to evaporate the water. As a result this hot water flashes into very wet steam as it comes through the cock, giving a jet consisting of finely divided water particles, intimately mixed with a large volume of steam.

Ammonia not precooled, flashes in the expansion valve in the same way. As a result there is a large volume of vapor entering the refrigerating coils along with the liquid.

If the ammonia is precooled to a temperature near that of the refrigerating coils, only a minute part of the liquid flashes in the valve, and most of the ammonia passes through in liquid form, like water from a faucet, and completely fills the coils near the valve. Farther on in the coils the absorption of heat causes vapor to be formed. In this case the quantity of liquid entering the coils is much greater than when precooling is not employed, which materially improves the rate of heat transfer and increases the capacity of the coils.

So far only one side of the question of precooling has been presented. The other side, of equal importance, is introduced by the question, What does it cost to secure the advantages promised by precooling? To this the answer depends on the way in which the precooling is accomplished.

Methods of Precooling.

Let us consider the following methods of precooling liquid ammonia: (1) By the use of the same water as is used for the condenser; (2) by using the makeup water entering a cooling-tower system; and (3) by using another, colder water, such as artesian or other well water. These three are external sources of cooling, and should be distinguished from internal sources of cooling, such as (4) by giving up heat to low-pressure ammonia (precooling by direct refrigeration); (5) by giving up heat to cold brine (indirect refrigeration); (6) by giving up heat to evaporating ammonia at an intermediate pressure.

The cost of the first three methods, aside from added equipment, may be regarded as only the cost of extra water used, including its delivery to the precooler. In the last three methods the heat of the liquid ammonia passes to a refrigerated element of the system, so that the cost of precooling is in the form of an increased load on the compressor. The cost or loss may be as great as the gain, but such a statement should not be made without careful analysis of the case.

If the same water is used for precooling as for the condenser, not much precooling can be accomplished, but its results may be worth while. With a counter-current double-pipe precooler, the liquid may be reduced to within three or four degrees of the coldest water coming to the condenser. The liquid ammonia leaving the condenser is commonly 15 to 20 deg. warmer than the coldest cooling water. In such a case ten to fifteen degrees of precooling could be obtained, which means an increase of the capacity of the entire plant of 2 to 4 per cent, with no increase of horsepower.

Where water is expensive, as when city water is used or where it must be pumped a long distance, cooling water for the condenser is used over and over and is cooled by partial evaporation in a cooling tower or spray pond. The temperature to which the water can be cooled depends on the temperature and humidity of the atmosphere and on the efficiency of the tower. Generally, in the summer time the water from the tower is warmer

than that which is drawn from the underground mains to make up for the loss by evaporation. When there is such a temperature difference, precooling by the makeup water is advantageous.

The difficulty often encountered here is that the quantity of makeup water is insufficient to cool the liquid to anywhere near the temperature of the lowest water.

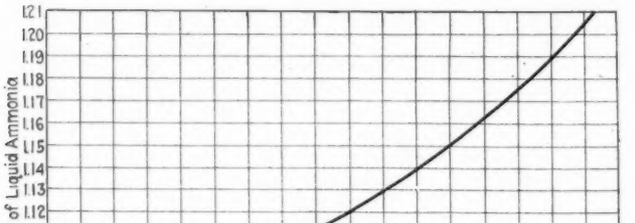


FIG. 1—SPECIFIC HEAT OF AMMONIA AT VARIOUS TEMPERATURES

To overcome this condition, it generally pays, unless the water charge is unusually high, to use a little more water than is demanded for makeup, for the sake of obtaining complete precooling. To accomplish this with a double-pipe cooler arranged for counterflow, the cooling water must be of large enough quantity to have a heat capacity somewhat greater than that of the ammonia that is being cooled.

Amount of Precooling Water

An approximate rule for the quantity of cooling water for use in a counter-current double-pipe precooler for the liquid ammonia is not less than one gallon per minute for every fifteen tons refrigerating capacity. The following example will give the reason for this statement and the basis for making calculations for special cases.

Suppose that in a refrigerating plant of 100 tons capacity, the average summer conditions are as follows:

Temperature of liquid ammonia leaving condenser.....85 deg. F.
Makeup water required for the cooling tower.....2½ gal. per min.
Temperature of makeup water .....60 deg. F.
Weight of ammonia passing expansion valve.....42 lb. per min.

First, assume that the 42 lb. of ammonia and the 2½ gal. of makeup water are passed through a counter-current double-pipe cooler having enough surface to bring the outgoing water to a temperature of 80 deg. F. The weight of 2½ gal. of water is 20.8 lb., the temperature rise is 20 deg., and therefore the water absorbs $20.8 \times 20 = 416$ B.t.u. per min. This heat is taken from the liquid ammonia, and the increase in refrigeration is found by dividing 416 by 200, giving 2.08 tons added refrigeration. This is a valuable gain, considering that it is at no expense except the installation of the double-pipe precooler.

But is this all the gain possible? Let us examine the temperature of the liquid leaving the cooler. The average specific heat of liquid ammonia between 80 and 60 deg., by Fig. 1 is 1.14. The temperature drop in 42 lb. of liquid due to the removal of 416 B.t.u. is $\frac{416}{42 \times 1.14} = 8.7$ deg., and therefore the liquid leaves the cooler at 85 — 8.7 =76.3 deg. F. So long as 60-deg. water is available, much more cooling is possible by using more water. This incomplete cooling process is illustrated by the upper set of curves in Fig. 2, showing relative temperatures when the water supply is deficient.

If a sufficient quantity of water is used so that its heat capacity is at least as great as that of the liquid ammonia, then the liquid may be cooled nearly to 60 deg. if enough cooling surface is provided. The heat capacity of the ammonia liquid is $42 \times 1.14 = 47.9$ B.t.u. per deg. The quantity of water that would have this heat capacity would be 47.9 lb. In this case the rise of water temperature and the fall of liquid temperature will be equal. It would be reasonable to design the cooler to bring the temperature of the liquid down to 68 deg. F. with a constant temperature difference throughout the cooler of 8 deg., and a cooling range, from 85 deg. to 68 deg., of 17 deg. Then the heat thrown off by the liquid ammonia is $42 \times 1.14 \times 17$ deg. $= 814$ B.t.u. per min., which, divided by 200, is 4.07 tons increase of capacity. This cooling process is illustrated by Fig. 2-B.

The weight of water used, 47.9 lb. per min., is equivalent to 5.75 gal., or 1 gal. per min. for every 17.4 tons capacity of plant. This is the least that should be used in the precooler for efficient work, and it is better to use more. It is best to say that the quantity of water used

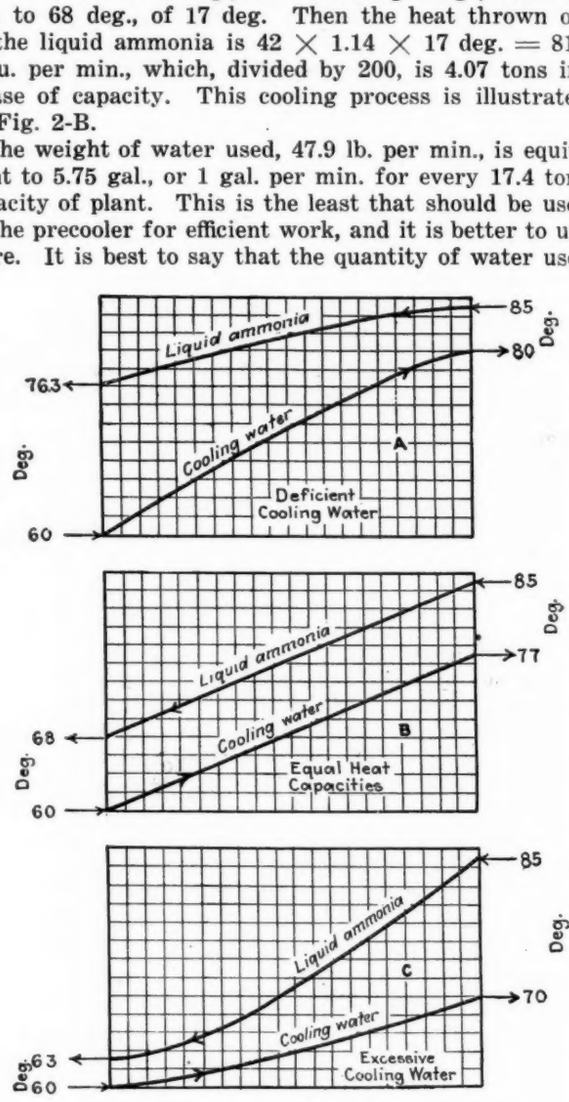


FIG. 2—EFFECT OF VARIATION IN COOLING-WATER SUPPLY

for precooling should not be less than one gallon for every fifteen tons capacity, as already stated.

When a large quantity of water is available, the ammonia liquid can easily be brought more nearly to the cold-water temperature, in which case the temperatures are about as shown in Fig. 2-C.

Some plants situated close to a pond, lake or river,

pump water from that source, use it only once and return it. It may be that this water is the coldest available. If, however, it is possible to draw on city mains, wells or artesian water of a lower temperature, it is probable that its use will be profitable. It has been shown how to estimate the gain. Against this weigh the cost of the extra water, including a charge to pay the cost of installing the cooler, and it will quickly be seen whether it is a paying investment under any given set of conditions.

In the three foregoing cases precooling was secured by the use of water. The cost was limited to charges for installation of cooler and possibly a pump, and for use of extra water. When the precooling is done by expanded ammonia or cold brine, it offers another aspect. The heat from the precooled liquid goes into the expanded ammonia or brine and uses up some of the refrigeration that has already been produced. It appears like robbing Peter to pay Paul, and may be so if the case is not carefully studied.

If the precooling is done by expanded, low-pressure ammonia, the loss and the gain are equal, so far as the direct effect on the work of the compressor is concerned, but the liquid, precooled to the temperature of the low-pressure gas, does not flash into vapor in the expansion valve, as explained earlier, with the result that the heat transfer in the coils is more rapid, tending to raise the back pressure, increase the capacity and improve the economy of refrigeration. The effect in this way is sufficient to warrant the employment of this type of precooling.

Precooling by means of brine is mentioned as a possible method, but seldom employed, as it involves the same losses as in case of precooling with ammonia with the added loss due to the extra heat transfer as well as that of brine pumping.

Precooling with High Back Pressure Ammonia.

In plants using two back pressures (which may be obtained by compounding, by the use of multiple effect, or by the use of a second compressor for the high back pressure) a useful practice is that of precooling the liquid by means of ammonia expanded at the higher back pressure. Refrigeration is produced much more economically at the higher back pressure. Applying this more economical refrigeration to liquid cooling has the effect of transferring that part of the refrigeration to the higher temperature plane and therefore securing more low-temperature refrigeration at a lower cost than normal.

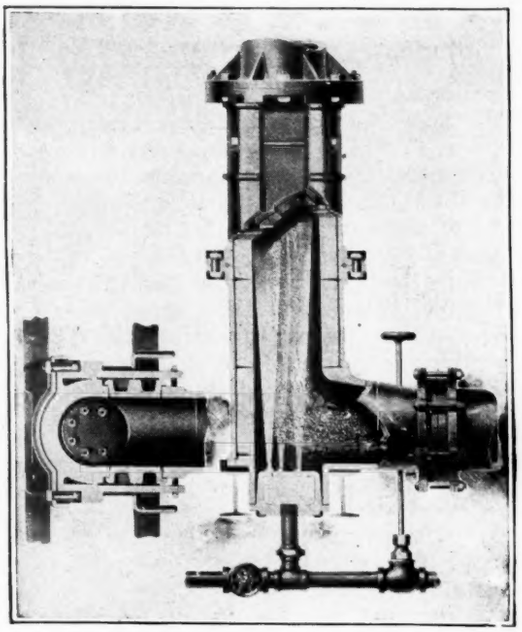
The use of the higher back pressure for precooling is easily applied in conjunction with the forecooling of ice-making water by the same means in ice plants, where it is possible to do a large fraction of the work of the plant at the higher pressure.

In a large plant, where economies are of importance, all the methods of precooling should be given consideration. Generally, the best results will come from the combination of two or more methods. It may be best to precool first with the same water as used for the condenser and afterward to utilize cold well water. Water cooling, use of ammonia expanded at the higher back pressure, and final cooling by low-pressure ammonia may all be used to advantage. To secure best economy, as much as possible of the cooling should be done directly by cooling water before any cooling is done by ammonia. It is evident that precooling may be advantageous under favorable conditions.

New Steam-Jet Ash Conveyor Has Six Nozzles

Primarily to reduce wear and incidentally to increase the suction with the same quantity of steam, the M. H. Detrick Co., of Chicago, has improved its steam-jet ash conveyor by a new nozzle arrangement with heavy-duty fittings on all 8-in. conveyors. Instead of using a single nozzle at the center of the pipe, six nozzles are screwed into a manifold casting on a diameter about two inches less than the internal diameter of the pipe.

With the previous single-nozzle fitting, the expanding steam tended to block off the ash coming in from the suction line, and upon entering the elbow, the ash was



PLAN AND ELEVATION OF DETRICK-HAGAN ASH CONVEYOR

hurled outward against the wearing backs of the fitting, the impact and the scouring action resulting in rapid abrasion. With the six nozzles set so that their axes converge toward a central axis at an angle of two degrees, a funnel of steam is formed in which the ashes are compressed and held in the center of the pipe. Undoubtedly, some of the ash will penetrate this film of steam, but the tendency will be for the greater portion to be carried up in the pocket thus formed, so that the wear on the liners should be reduced.

On test, with the steam pressure constant throughout, it was demonstrated that the six nozzles would produce 10 per cent greater suction than a single large nozzle, the throat areas in the two cases being equal. When first installed, the pipe surface is usually rough, offering maximum resistance to the flow and requiring more steam to pull the ashes through than later on when the surface has been worn smooth. With surface friction reduced, it may be possible to eliminate the two end nozzles, substituting plugs in their places and thus lessen the steam consumption.

In the elbow itself there have been some minor changes, such as the provision of a cover at the front to facilitate the removal of the wearing backs on this side, the bolting of both back and cover to the body, the casting of lugs on the wearing backs to ease the pulling-out process, and the provision of handholes.

Power Plant of the Hawaiian Electric Company, Ltd., Honolulu

By H. W. MARVIN*

CONTRARY to the opinions held by many engineers that power plants in sub-tropical countries are inefficiently designed and operated, the station built in 1918 by the Hawaiian Electric Co. to meet the increasing power requirements on the Island of Oahu compares favorably with present practice.

Owing to its location approximately 21.5 deg. north latitude, several conditions were already laid down, and the station was designed with these in view: First, all fuel oil has to be imported at approximately the San Francisco price plus 85c. per barrel freight; second, the available circulating water has a temperature of from 74 to 84 deg. F.; third, it was necessary to provide for continuous operation, as there are no interconnecting plants to absorb the load in cases of emergency, and the Island of Oahu depends on this plant for light and a large part of its industrial power.

The building is of reinforced concrete with the exception of the roof trusses and boiler supports, which are steel. Its main architectural features are the well-proportioned windows and cornice. The boiler room is 108x-150 ft., and provisions have been made in its general design to provide for changing to coal if the oil supply fails.

*Chief engineer, Hawaiian Electric Company, Ltd.

At present six steel-incased 8,226-sq.ft. Stirling boilers are installed, with space allotted for six more. Thus there is an allowance of approximately one square foot of floor area for each four square feet of boiler-heating surface. Boilers operate at 300 lb. gage and 200 deg. F. superheat, or a total steam temperature of 622 degrees.

The boilers are supplied with water at from 260 to 270 deg. F. through an open feed-water heater and economizers.

A triple system of boiler feed-water piping is installed. Water can be fed direct to the boilers either through the back drum, blowoff connections or through the economizers. Two four-stage centrifugal pumps driven by turbines supply this water at 325 lb. pressure. Oil is supplied to the burners at 90 lb. pressure and a temperature of 180 deg. F.

The chimney is reinforced concrete connected to the economizers and boilers with a bypass reinforced-concrete flue.

Steam piping in the boiler room consists of a cloverleaf loop cross-connected to the header in the turbine room. All piping 2½ in. and up is fitted with vanstone joints and provided with special cast-steel flanges and special size bolts. All piping 2½ in. and smaller is

PRINCIPAL EQUIPMENT OF THE POWER PLANT OF THE HAWAIIAN ELECTRIC CO., LTD.

BOILER AND SUPERHEATERS

Manufacturer	Babcock & Wilcox Co.
Type	Stirling
Number, installed	6
Number, ultimate	12
Water-heating surface, sq.ft., each	8,226
Boiler pressure, lb. gage	300
Superheaters, type	Foster
Manufacturer	Power Specialty Co.
Superheat, deg. F.	185-200
Steam temperature, total deg. F.	620
Kind of fuel	Oil

CHIMNEYS

Builder	Heine Chimney Co.
Type	Reinforced concrete
Number, present	1
Number, ultimate	2
Height above foundation	224 ft.
Diameter at top, ft.	12 ft., 6 in.

ECONOMIZERS

Manufacturer	Green Fuel Economizer Co.
Type	Counterflow
Number, installed	3
Number, ultimate	6
Heating surface, sq.ft.	7,862

OIL-BURNING APPARATUS

Pumps, simplex	Worthington Pump & Mch. Corp.
Heater	C. C. Moore
Burners	Hammel Oil Burning Equipment Co.
Type	Back-shot

FEED-WATER PUMPS

Manufacturer	Worthington Pump & Mch. Corp.
Number, installed	2
Number, ultimate	4
Type	Jeansville 4-Stage Centrifugal
Capacity, gal. per min.	420
Drive, turbine	Westinghouse Elec. & Mfg. Co.
Speed, r.p.m.	2,700

FEED-WATER HEATERS

Manufacturer	H.S.B.W. Cochrane Corporation
Type	Open
Number, installed	1
Number, ultimate	2
Capacity, lb. per hr.	125,000

GENERATING EQUIPMENT

Manufacturer	Westinghouse Electric & Mfg. Co.
Type	Turbo-Alternator
Number, installed	Two-12,500 kw.
Speed, r.p.m.	1,800
Pressure at throttle, lb. gage	290
Temperature at throttle, deg. F.	600
Guaranteed performance, lb. per kw.-hr.	12
System of lubrication	Continuous, with bypass filter system
Generators	3-phase, 60-cycles, 11,000-volt
Exciters	Westinghouse Electric & Mfg. Co.
Number	2-75 kw., 250 volt
Drive	One motor, one turbine

CONDENSERS

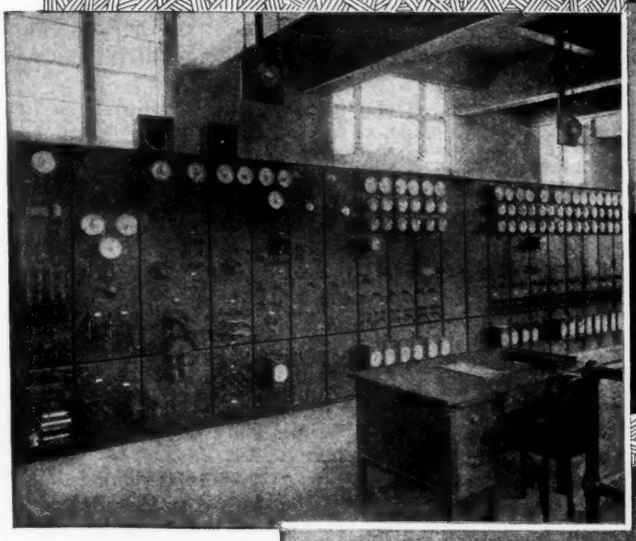
Manufacturer	Alberger Pump & Condenser Co.
Type	Surface
Number, installed	2
Tube surface, sq.ft.	17,910
Sq.ft. of surface per kw.	1.35
Circulating pumps, 10,000 gal. per min.	2
9,000 gal. per min.	2
Type	Slow-speed centrifugal
Manufacturer	Alberger Pump & Condenser Co.
Drive	One 100 hp. a. c. motor-driven One 100-hp. turbine-driven One 75-hp. a. c. motor-driven One 75-hp. turbine-driven
Condensate pumps, number	4
Manufacturer	Alberger Pump & Condenser Co.
Capacity lb. per hr., each	125,000
Drive	Two motor-driven, two turbine-driven
Air Pumps	2 Alberger Pump & Condenser Co.
Type	Alberger A.E.G.
Number	2
Drive	Turbine
Air Occluders	One set

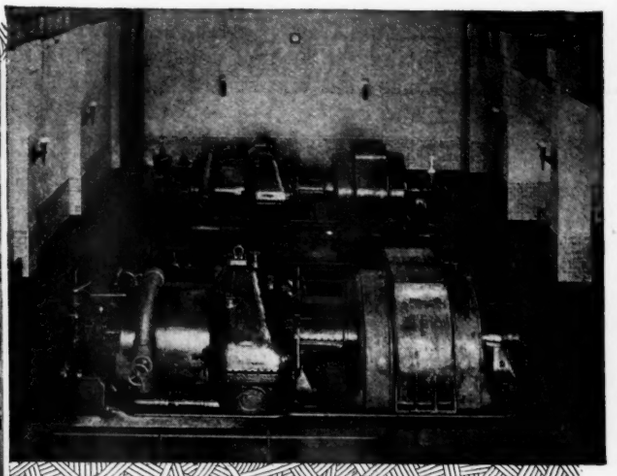
SWITCHBOARD

Manufacturer	Westinghouse Elec. & Mfg. Co,
Type	Remote control

MISCELLANEOUS EQUIPMENT

Feed-Pump Governor	Foster Engineering Co.
Piping	Crane Co.
Safety valves	Crane Co.
Blowoff valves	Babcock and Wilcox Co.
Stop valves	Edward Valve & Mfg. Co.
Other valves and pipe fittings	Crane Co.
Pipe covering	National Magnesia Co.
Steam traps	Crane Co.
Oil filtration	Richardson-Phoenix Div. S. F. Bowser & Co.
Steam-flow meters	General Electric Co.
Recording Gages	Brown Instrument Co.
Indicating Gages	Ashcroft Mfg. Co.

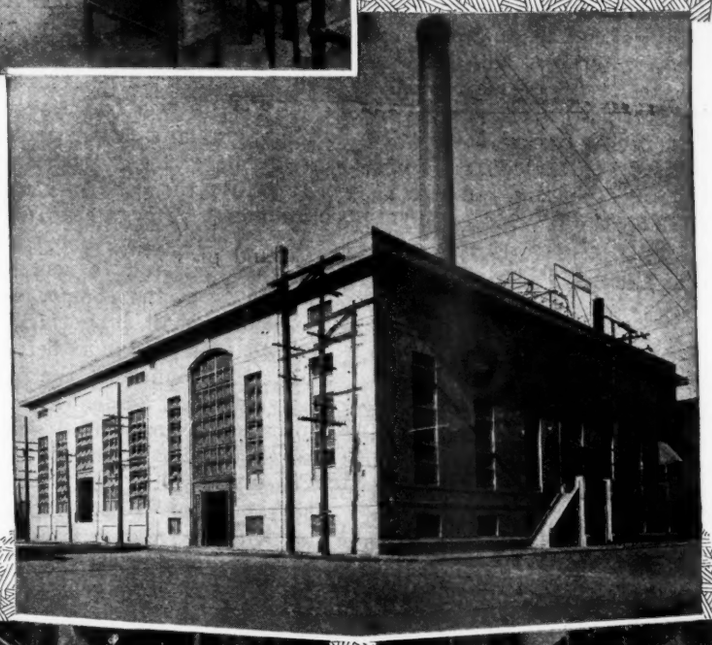




Above: Remote-control switchboard.

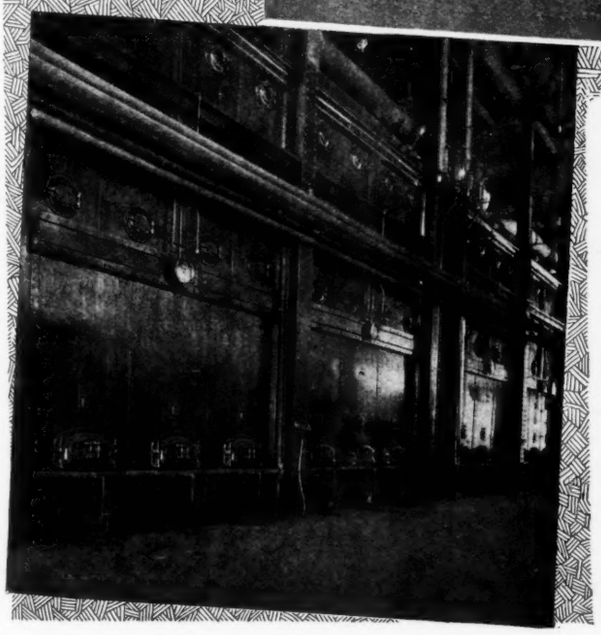
Right: Exterior view of power plant.

Below: Front view of 8,226-sq.ft. boiler, oil-fired.



Above: View of turbine room, showing two 12,000-kw. units.

Below: Simplex oil pumps and four-stage centrifugal feed pumps.



screwed and brazed. Valves throughout are designed for 350 lb. pressure 800 deg. F. total steam temperature, and are fitted with Monel metal seats and disks and special flanges. Fittings 2 in. and smaller are forged steel, except that lines that are subject to exceptional strain by heating and cooling, are equipped with ammonia malleable fittings screwed and brazed on.

TURBINE ROOM

Two 10,000-kw. 11,000-volt three-phase turbo-alternators are installed at present with space allotted for one additional unit. These machines are designed to operate with 290 lb. pressure, 185 deg. F. superheat and 28 in. vacuum.

The condensing equipment consists of two surface condensers of 17,900 sq.ft. each. Each condenser is provided with two slow-speed centrifugal pumps, one driven by a steam turbine and the other by an alternating-current motor. Two hotwell pumps are installed and these are also steam and motor driven. Both condensers are connected to a 12-in. air header, which in turn connects to two entrainment pumps and one set of air occluders. The circulating water is supplied through concrete flumes connected to the Honolulu Harbor. These flumes are cross-connected so that the suction and discharge can be reversed for killing the marine growth.

The remote-control switchboard is located on the same floor level as the turbines. Switches and busbars are on the gallery floor directly above.

Repair of Fractured Piston

BY COLIN K. LEE

While operating two 25-hp. semi-Diesel oil engines, we were bothered for a time by the appearance of holes through the piston heads. The engine would suddenly quit cold, after perhaps a day or so of gradual weakening of the compression. Upon removing the cylinder head, a ragged hole would be found eaten through the center of the piston head, as though by the action of some strong acid. It was necessary to remove the piston and carry it to a machine shop forty miles away to have the hole filled by gas welding.

Gas welding is frequently undesirable, owing to the scarcity of really competent operators, but we found a specialist whose work was invariably satisfactory. His success was attributed largely to his care in cleaning, preheating and annealing, and to his skill in allowing for expansion. This man cleaned out all the burned metal from the hole, preheated the entire piston for half a day, filled the hole with new metal and annealed it twelve to sixteen hours. This was done on both engines successfully and repeated. The method was finally abandoned, since there was a tendency to warp the skirt of the piston as it was unsupported through the middle. On one occasion the piston had to go back to the shop and be turned down slightly, causing still further clearance on an already loose piston. So a method outlined a year or so ago in *Power* was tried. A steel plate was set in the head, covering the hole, flush with the surface, and secured by flush screws. A cast-iron plate would have been preferable, to secure uniform expansion, but was not available. Clearance was allowed around the plate to care for the slight expansion of the metal. This method was far quicker and cheaper than welding. Very close observation was kept of this plate for a time, but it was found secure after a year's use.

The method of "sewing" the cracked piston heads with overlapping threaded plugs was also tried, but was found to be suitable for thin cracks only. The iron around the plugs had a tendency to burn away, and the sewing could not be done repeatedly on the same piston. It was in general successful, being fairly quick and cheap.

The erosion of the pistons was attributed to heavy loading of the engines, which would cause the piston to receive more heat than it could transfer to the cylinder walls. However that may be, the loading of the engines was slightly reduced, and the erosion of the pistons practically ceased.

Refrigerating Condenser Cooling Water

BY H. J. MACINTIRE

Last summer I met a practical contracting and erecting engineer who had a real application of the "boot-strap" proposition applied to refrigeration. His condenser cooling water was too hot (about 84 deg. F.) with the result that the condenser pressure was over 200 lb. gage. As he realized that a head pressure of over 200 lb. was bad for his compressor capacity, as well as the horsepower per ton and the temperature of the discharged gas from the machine, he arranged to refrigerate the condenser cooling water to 64 deg. F. No amount of argument would convince this engineer that the use of vaporizing ammonia to cool the water to be used to cool and condense the gas discharged from the compressor was incorrect in theory and could result in nothing but a practical loss. He insisted on his idea as being practical and economical, and in this connection the following may be of interest:

Assume that 84-deg.-F. water is used over the condenser at the rate of 3 gal. per ton per minute. To cool this water from 84 to 64 deg. F. would require 20 *deg.* $\times$ 3 *gal.* $\times$ 8⅓ *lb.* = 500 *B.t.u., or* 2½ *tons of ref.* Using 3 gal. of 64-deg. water per minute, the head pressure will be reduced from 200 to 140 lb. gage. The brake-horsepower per ton at 20 lb. gage suction pressure and 200 lb. gage head pressure, assuming 82 per cent volumetric efficiency and 10 per cent mechanical loss, is 1.6, while with 140 lb. gage head pressure, 86 per cent volumetric efficiency and 10 per cent mechanical loss the brake-horsepower is 1.1 per ton. The power required is reduced by 0.5 hp. per ton, but at the cost of 2½ tons of refrigeration.

Stated another way, by using 2½ tons of refrigeration to cool the condensing water, one ton of refrigeration of useful work was obtained. If the compressor itself is used to provide this cooling of the condensing water, the extra 2½ tons of refrigeration will require (at the same rate) 7½ gal. of water per minute to be showered over the condenser. This likewise must be refrigerated in order to have its temperature at 64 deg. F., which is impossible, and the whole problem is absurd. We cannot lift ourselves by means of our boot-straps, nor can we refrigerate our condenser water and gain in the process.

If the winding of an air-cooled transformer requires drying out, this may be done by short-circuiting the secondary winding and applying sufficient voltage on the primary terminals to cause about one-fifth full-load current to flow, care being taken not to allow the temperature to exceed 90 deg. centigrade.

Setting the Crankshaft Bearings of Internal-Combustion Engines

By H. F. SHEPHERD

In the event of crankshaft failure or even of ruined bearings the question arises as to who is at fault. Either the crankshaft was not properly bedded in the bearings by the erector or the operator failed to adjust the alignment to compensate for the natural bearing wear or the shaft was too light for the duty imposed upon it.

BACK in the days of my apprenticeship the old home town ordered two engines for the borough light plant. The local mechanics, some of them geniuses in their way, awaited the arrival of these engines with great curiosity, which was gratified before the engines left the flat car. Next, with equal curiosity they awaited the appearance of that far-traveled sage among mechanics, the erecting engineer. He came and, to our great surprise, carried no tools save one scraper, which it was darkly whispered was not a scraper of the length and fashion approved by the local tradition. Shortly he appeared at the works to borrow tools and was told that he might use our equipment if he paid for the service of one man at the regular journeyman rate while the tools were in use. The condition amounted to a conventional way of establishing the rate of payment for the use of the tools no doubt, so I, by

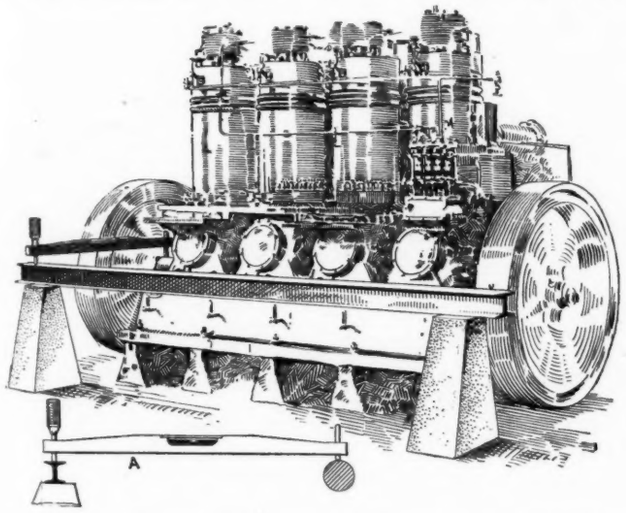


FIG. 1—CHECKING THE ALIGNMENT OF A CRANKSHAFT

no means a journeyman, was sent along as sort of a deputy to the chain blocks.

To proceed with the tale, the erector put lines through the engine lengthwise and transversely and squared them up by the three four five method. By this means he located his outboard bearing. The shaft was laid in, carefully leveled with the wheel and generator on, and the outboard bearing was then elevated, as I remember, one sixty-fourth of an inch. This in itself was a scandal. Our local job-shop experience did not run to careful consideration of deflections. Shortly after this our erector was called away and another man was sent out to line up the second engine. He blued the main bearing, laid the shaft in place with an approximate setting of the outboard bearing, rolled the shaft and studied the markings on the blue to learn whether it was down and

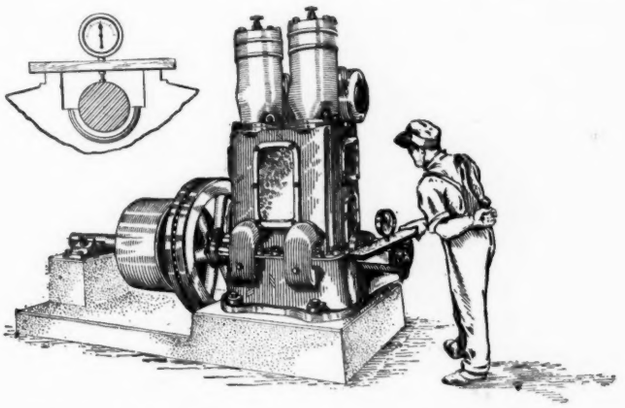


FIG. 2—ACCURATE METHOD OF BEDDING A SHAFT

square in the bearing. Of course it was not, and he proceeded to elevate the outer bearing and to adjust it horizontally until he made the shaft lie properly in the main bearing and align properly with the connecting rod at the four quarters.

Much argument ensued as to which erector chose the proper method. The incident started me on a chain of experience and observation which probably never will be complete.

Bowing of Crankshaft

Some years later, while employed on the erecting floor of a works large enough and famous enough to satisfy the yearnings of my apprentice days, I witnessed a queer performance. A large multi-cylinder engine was set up on the floor plate, the flywheel slung on each end of the crankshaft and the bearing caps removed. The main bearings were of the type that could be adjusted by elevating wedges. A planed I-beam was set up parallel to the crankshaft just outside the engine base. A curious tool was brought, being made somewhat as shown at *A* in Fig. 1. At one end was a hardened point, at the other end was a micrometer screw. In the middle of the horizontal bar was a sensitive level. With this device the I-beam straight-edge and the crankshaft end bearings were brought into careful alignment. Then the leveling tool was applied on the journals at the center bearings. It proved that under the influence of the wheel weights the shaft was bowed a considerable amount in the center. An attempt was made to bring the shaft straight by coming down on the center bearing caps. The result was a very hard running shaft.

This experiment, I was told, had come about through the investigations of a civil engineer who had endeavored to help field mechanics replace a crankshaft. The

erector adjusted the center bearings in the usual fashion; that is, by pulling them up to the shaft when the shaft was correctly aligned at the ends, having the wheel weights on it. The civil engineer then set up his instrument and leveled it with the end bearings. Upon swinging the instrument to the center bearings, the engineer insisted that they were high. The erectors laughed at him and proceeded to assemble the engine in the usual way. The shop experiment proved the civil engineer very nearly correct in his measurements.

Out of this it was decided that the center bearings must be so aligned as to allow the crankshaft to assume its natural bow under the weight of the flywheels. No doubt certain mental reservations were made at the same time never again to design an engine with a long crankshaft and two overhanging flywheels. Vertical engine practice now generally uses one flywheel at the drive end, and this flywheel is supported by an outboard bearing.

Test for Alignment

A little later perhaps, a certain designer discovered that when the center bearing of his engine was out of its normal position, a test indicator applied vertically to the shaft would show movements of the shaft in the vertical plane. He therefore provided fixed test indicators at each bearing as part of the engine equipment. Of course the inertias in his engine were not sufficient to lift the shaft, so he could test running. He fixed the end bearings and provided an adjustment for the center bearings. The engine used two flywheels, unsupported as was usual at that time. The principle involved, consciously or unconsciously, is that the shaft is subject to the least vibration when it lies naturally in its bearings. The wheel weight will keep it down in the end bearing. It will bow out of the center bearings and against their caps if all bearings are dead in line. Upon application of pressure the shaft will be deflected

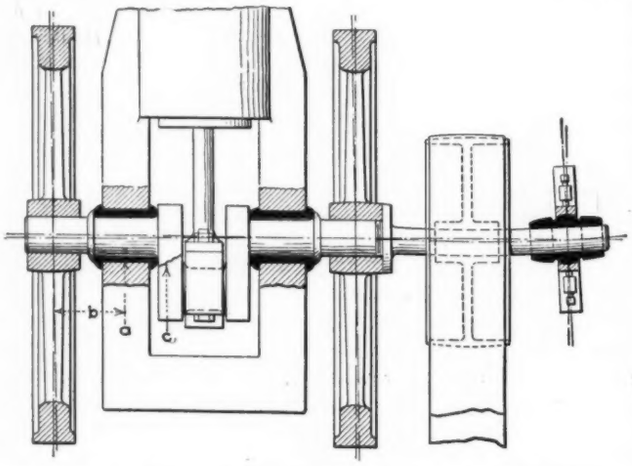


FIG. 3—EFFECT OF DEFLECTION IN A CRANKSHAFT

downward to return immediately as under the influence of a strong spring, the shaft itself being the spring. This motion will of course be evident in the action of the test indicators of the center bearings, which latter are elevated until the test indicators on all bearings show no vertical motion when the engine is in operation. The test indicators at the end bearings are useful in showing too much elevation of the outer bearings or too much elevation of the outboard bearings when used with one flywheel.

A sort of reaction or change of fashion took place in the design of beds for vertical engines following these developments. We are concerned here with operation, and as there are possibly more gas engines in use with adjustable bearings than without, it is not our business to draw comparisons favorable or unfavorable. If the engine is to have two overhanging wheels, very certainly the center bearings must be adjustable. If it has one flywheel and an outboard bearing, it does not matter so much. The main point is that the oper-

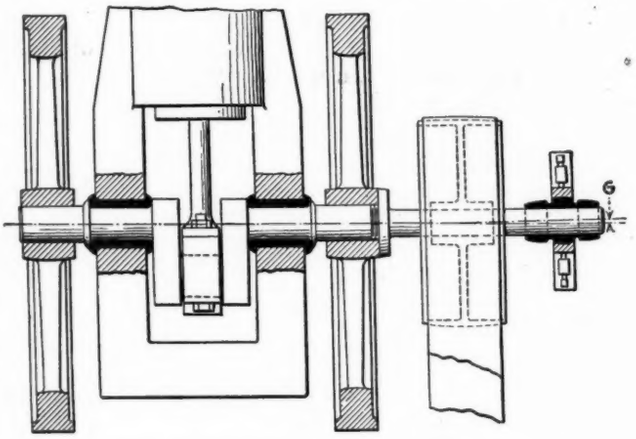


FIG. 4—METHOD OF CORRECTING SHAFT DEFLECTION

ator should understand the principles involved. The steam-engine trade has recognized and provided for shaft deflections for a generation or more, while the combustion-engine trade has had to grow into the knowledge as a new experience.

When the solid bedplate was first adopted for vertical gas engines, the two overhung wheels were still used. The first one of these machines that came to my attention as a repairman had a fashion of breaking its center bearing shells. I stripped it down to the center line, hung the flywheels on and scraped in a new set of end bearing shells, finding as I did so that considerable more scraping was done near the flywheels than at the inner edges. In fact the scraping brought a bearing progressing from an inch or two at the outer edges and extended by scraping the largest amount of metal from the outer part until it reached clear across. I then set up a test indicator and learned that the shaft stood a thirty-second-inch high in the center. Center bearings were made accordingly, the whole scraped in to a good bearing, and for the first time in the existence of the engine we had a sweet running shaft. This is further evidence of the necessity of allowing a shaft to take its natural bow under wheel weight deflection, but it is stronger evidence that where the solid bedplate is used, only one flywheel should be fitted, this being at the driving end and supported by an outboard bearing.

Proper Position of the Shaft

The operator and the mechanic with a very little stretch of imagination can usually picture in his own mind the shape that a shaft would take under various loadings, and in fitting bearings this should always be remembered. If the mechanic is not trained to think in this way, a wooden staff set up in V-blocks and loaded will give a pretty accurate idea of the nature of the deflections. Let us make it clear again; generally speaking, gas-engine bearing caps are not intended to restrain the shaft into place. The shaft should lie in its bearing.

To accomplish this in the case of the vertical engine as now built with one flywheel and an outboard bearing supporting it, the outboard bearing must be adjustable vertically, especially if the main bearings be of the non-adjustable type. The amount of its adjustment above the normal center line will depend on the size and length of the shaft extension, and the weight which this extension supports. The operator is concerned with adjustment rather than design, and no fixed and definite rule can be given.

For this work of adjustment I prefer a test indicator or a depth micrometer used with a parallel as shown in Fig. 2. Set the test indicator on the bearing next the flywheel, elevate the outboard bearing until you just begin to lift the shaft out of the main bearing next the flywheel; this will be indicated by watching the test indicator. You now have a little too much elevation, as this main bearing is not carrying its proportion of the weight. Move the test indicator, then, to the second main bearing, as shown in Fig. 2, and first marking the previous adjustment, lower the outer bearing until the shaft starts to assume a bow, slightly lifting the second journal from its bearing. The proportion of the weight carried on the first main bearing is now a little too great. How much so depends somewhat on the stiffness of the shaft. The outboard bearing must now be elevated again to insure proper lie of the whole shaft. I should say that if it is elevated one-third to one-half of the difference in the two previous adjustments, a satisfactory compromise is made.

Compensation for Belt Pull

The belt pull may influence the lie of the shaft and the bearings, especially if the belt drive is a very tight one and the shaft extension slender. Fig. 3 indicates a condition in a horizontal engine. Some years ago I ran across this state of affairs in a field where a number of similar engines were installed. They had started out on a career of destruction, breaking shafts and bearing caps, and sometimes carrying the bedplate along. The outboard bearing had been aligned exactly with the main bearings with the belt removed. On throwing the belt on, a condition similar to Fig. 3 was established, the off wheel being thrown against the back of the bearing. When the explosion occurred in the cylinder, the off wheel was thrown forward, delivering with its mass and travel a terrific blow on that main bearing at *a*. It immediately sprang back, delivering under its spring effect another hammer blow on the main-bearing cap, which was of the inclined type. Undoubtedly the wheel mass was such as to produce a periodic vibration under the influence of the explosion pressure. Serious vibrations were set up, causing shaft breakage. It was corrected by setting the outboard bearing back an amount as indicated at *G*, Fig. 4. First the outboard bearing was put in normal alignment. The belt was thrown on, the caps having been removed from the crankshaft. The shaft immediately sprang away from the off bearing. The outboard bearing was then set back against the belt pull until the shaft took its seat in the off bearing. The deflection recorded was almost beyond belief, which points the moral that designers should give more attention to enlarging shaft extensions at the center to withstand either weights or belt pull.

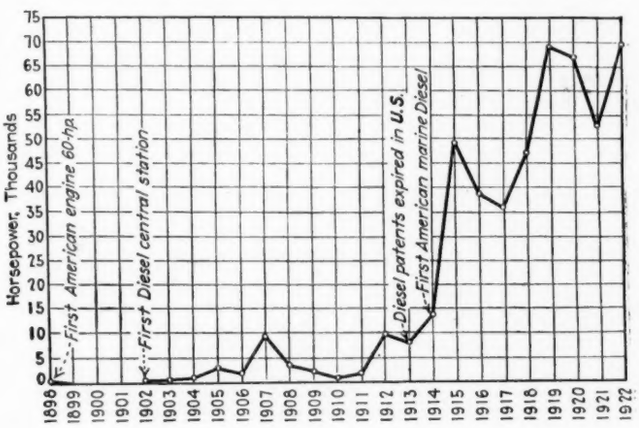
Once more let it be understood that the shaft must lie in its bearing. The designer should provide such bearings and shafts of such dimensions that serious deflections will not take place. Where he has gone sufficiently far or where he has failed, the erecting engineer and the operator must make such compensation in the alignment of bearings that the shaft will lie in each point of support. Of course the connecting rods must be removed when alignment is checked. A bowed shaft is subject to alternating stresses in revolution, and the mechanic is usually suspicious of such a condition. However, calculation usually shows that for the deflections encountered in practice the stresses are very low and not nearly as serious in their influence as the vibration set up when a shaft must be pushed to its seat every time pressure is applied. These vibrations may become an influence of greatest import if the mass of a flywheel takes part in them not torsionally, as we usually consider shaft vibration but transversely to the wheel plane.

Look, for instance, at the wheel shown in Fig. 3; imagine the shaft striking the bearing at *a* with high velocity due to the explosion and with a terrific impact due to the wheel weight. A turning effort is produced with the arm equal to the distance *b*. The weight of the wheel then rebounds and using the shaft as a massive spring, produces an opposite turning. These forces are resisted in the shaft arm at *c* and, if they become periodic, are most destructive.

Diesel-Engine Installations

In 1921 *Power* published a very complete survey of the Diesel-engine industry. In this was shown the horsepower of these engines installed in each state together with data as to the location by the various industries.

The illustration herewith is a reproduction of one of the charts included in the survey mentioned, extended



HORSEPOWER OF DEISEL ENGINES INSTALLED YEARLY

to include the years 1921 and 1922. It will be noticed that, although the output in 1921 was less than 1920, there was a marked recovery in 1922.

The horsepowers shown for 1921 and 1922 include the high-pressure solid-injection engines as well as the true Diesel units, but do not cover those engines requiring a torch for starting purposes even though termed by the makers as solid-injection engines. This chart is very illuminating as to the rapid recovery made by the oil-engine industry after the slump of 1921.

When compared with the reports of the Department of Commerce for 1921, it is found that the Diesel sales during that particular year were slightly greater than the sales of semi-Diesel engines.

Speed Adjustment of Direct-Current Motors—Variable-Voltage Systems

Multi-Voltage Systems Using as Many as Four Different Voltages—Variable-Voltage Systems Where the Generator Voltage Is Adjusted To Obtain Change in Motor Speed

By GORDON FOX
Electrical Engineer, Freyn Brassert & Company

IT WAS shown in a previous article that the speed of a direct-current motor may be varied by changing the voltage impressed upon its armature and how this may be accomplished by the insertion of series resistance. Other methods may be employed to obtain speed control by variation of applied voltage. The so-called "multi-voltage" system is sometimes adopted. Most commonly, this is arranged to provide 115 and 230 volts from a three-wire distribution system served by three-wire generators, rotary converters, balancer sets or generators connected in series. The field circuit of the motor is connected permanently to one voltage, but the armature may be connected across either voltage, series resistance being used during acceleration and transition periods, as usual. When operating at half voltage, approximately half speed results. As the motor is a normal 230-volt design and has no special features. This general method of speed control is well

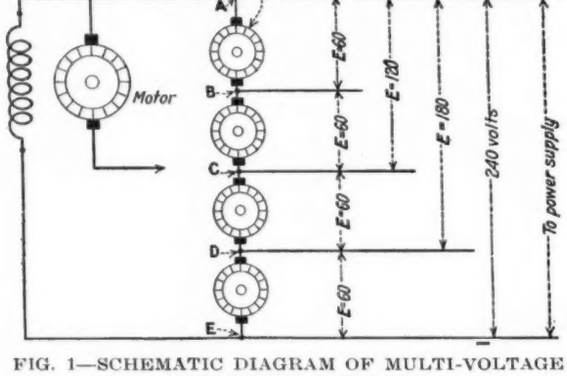


FIG. 1—SCHEMATIC DIAGRAM OF MULTI-VOLTAGE CONTROL SYSTEM

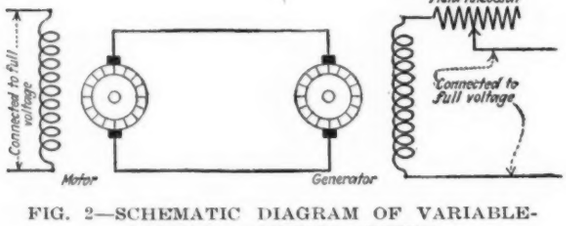


FIG. 2—SCHEMATIC DIAGRAM OF VARIABLE-VOLTAGE CONTROL SYSTEM

field strength is unchanged, the torque per ampere of armature current is not affected by the voltage used.

A motor used on a multi-voltage system has inherently a fixed torque capacity and may have a higher horsepower rating on the high than on the low voltage. The speed-torque characteristics on both voltages are similar and are determined by the motor. Thus a shunt motor will operate at practically constant speed on either 115 or 230 volts, the speed on the lower voltage being about half that on the higher. The

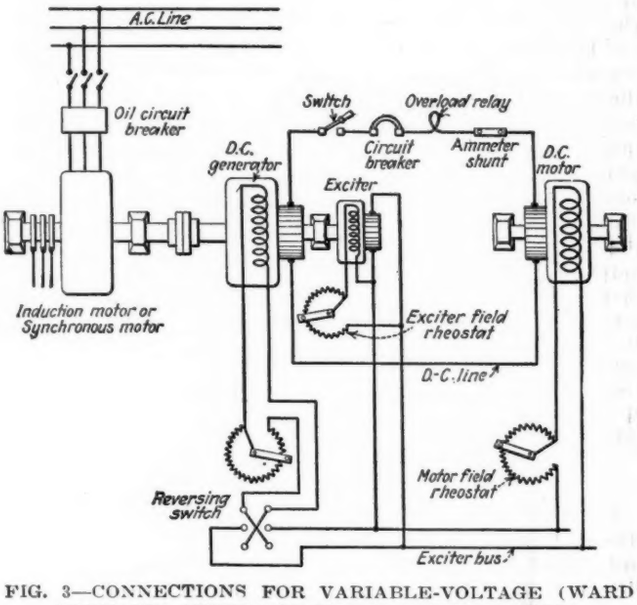


FIG. 3—CONNECTIONS FOR VARIABLE-VOLTAGE (WARD LEONARD) SYSTEM OF MOTOR SPEED CONTROL

suited in some cases where the load demand is of a constant-torque character, as a smaller motor frame may be employed than would be required for single-voltage operation with field control. This is because the higher speed is obtained with a strong rather than a weakened field and the torque per ampere is therefore greater. It is also occasionally used to minimize starting-resistance losses.

A system of multi-voltage control has been adopted, notable for elevator service, in which four voltages, respectively 25, 50, 75 and 100 per cent normal, are used. Fig. 1 is a diagram showing the general arrangement of the scheme. A balancer set that is capable of producing four different voltages is connected permanently across the line. The field wind of the elevator motor is also connected across full voltage. When starting, the motor's armature is first connected to points *A* and *B;* after it has accelerated to a certain speed, it is disconnected from *B* and connected to *C*, thus connecting to one-half full voltage. From there acceleration is obtained by disconnecting from *C* and connecting to *D*, to obtain three-quarters full voltage, and full voltage is obtained by disconnecting from *D* and connecting to *E*, where normal speed is obtained.

Where the importance of the drive warrants the use of an individual generator to supply power to a motor, the speed of the motor may be controlled by varying

the generator's voltage, which is also the motor voltage. The fields of both the generator and the motor must be excited from a separate source of constant potential. The armatures of the generator and the motor are connected together as indicated in Fig. 2. No armature resistance is necessary, as the motor can be started by building up the generator voltage from zero to any desired point by adjustment of the generator field strength. A wide speed range is afforded,

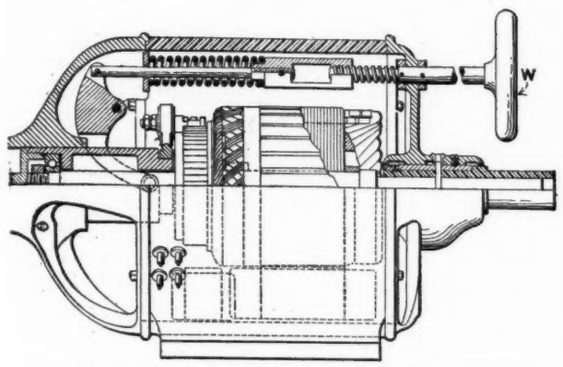


FIG. 4—SECTION THROUGH MOTOR IN WHICH ADJUSTABLE SPEED IS OBTAINED BY SHIFTING ARMATURE

ranging from a creeping speed to rated speed of the motor with maximum voltage. For any given generator voltage the speed of the motor, which is usually shunt wound, remains approximately constant, regardless of load. As the motor field is of constant strength, the torque per armature ampere is fairly definite and the drive has a constant-torque rating. Lack of ventilation at very low speeds may reduce the capacity. This variable-voltage method of speed control is commonly known as the Ward Leonard system, and has been used for elevator service as well as for industrial applications. Fig. 3 shows the general arrangement of machines and connections for a large industrial drive.

By reversing the fields of the generator, the polarity of the generated voltage may be reversed. This results in reversed rotation of the motor. The fact that both the direction of rotation and the speed may be controlled by manipulation of field circuits alone, involving low currents and low resistance losses, is of distinct advantage in the case of some motors where switching of heavy armature currents would be difficult or armature resistance losses would be excessive were ordinary methods used.

Armature-Shifting-Type Motor

The methods of securing adjustable speed thus far considered have involved changes of an electrical nature by means of inserting resistance in the armature or field circuit or other means of voltage adjustment. It is possible to obtain speed adjustment entirely by mechanical means. In one class of motors of this type in common use, Fig. 4, speed adjustment is obtained by gradually shifting the armature endwise along its axis away from its normal position under the main field poles, but turning the handwheel *W*. The machine is so constructed that shifting the armature does not alter the position of the mainshaft or pulley. When the armature is in its normal position, the motor operates at minimum speed. As the armature is shifted out from under the main poles, the effective area of the poles is reduced and the magnetic flux cut by the armature conductors proportionately decreases. The air gap is also increased by axial movement of the armature because the armature core is slightly tapered in the form of a truncated cone and the bore of the fields is similarly tapered. Increase in speed thus becomes necessary in order to maintain the counter-voltage. The farther the armature is shifted from under the main poles the faster it revolves.

With the armature in a given position the motor behaves practically as a constant-speed machine and maintains steady rotation under varying load. Motors of this type are thus truly adjustable-speed machines and have the same general characteristics as motors employing the field-resistance method of speed control. As the armature is shifted, the effective flux is reduced and the torque consequently decreased; the speed, however, increases. Since horsepower is proportional to torque and speed, this motor is essentially a constant-horsepower machine. It should be noted, however, that the starting torque available depends on the position of the armature. When starting heavy loads, the armature should be located well within the fields. This motor thus has a weak point as applied for frequent starting under high-speed conditions. Also, owing to the magnetic pull of the field upon the armature the latter has no end play except when located directly under the main poles.

Commutation is quite satisfactory in motors of this type. The fields are always saturated for the reason that the cross-section of the iron carrying the flux decreases as the armature is shifted laterally. As a result there is little more distortion under high-speed conditions than under normal low-speed conditions. In addition, interpoles are provided to give good commutating conditions. The characteristics of a shunt machine of this design are shown in Fig. 5, and in

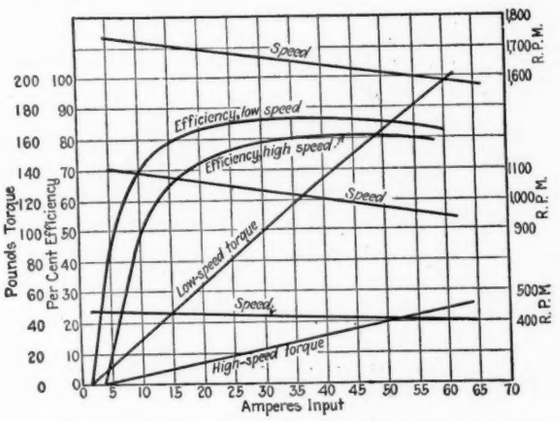


FIG. 5—CHARACTERISTIC CURVES OF 10-HP., 400- TO 1,600-R.P.M. ARMATURE-SHIFTING TYPE MOTOR

Fig. 6 are given those for an adjustable-speed shunt machine with field control of the same capacity, voltage and speed range. It will be noticed that there is a close similarity in the performance of the two machines.

A few advantages are realized in this type of motor. The speed changes are obtained by turning a handwheel attached to the motor frame, and there are available an unlimited number of intermediate speeds. Where the speed of a motor is adjusted by field control, the speed increases in steps corresponding to the points of the controller. The greatest advantage of the type of motor in which the armature is shifted, is in

the wide range of speeds available. With field control a range of 4 to 1 is usually a maximum. The armature-shifting method makes possible a range of speed as high as 10 to 1. This motor is therefore a suitable one to use where very wide range of speed is desired.

Not infrequently, two or more methods of speed control are combined either to obtain a wider range or to meet the drive requirements most effectively or with minimum cost. Armature control and field control are quite frequently combined to provide a wider speed

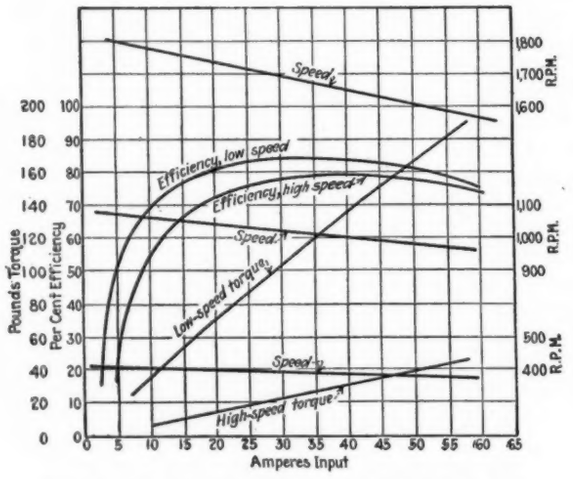


FIG. 6—CHARACTERISTIC CURVES OF 10-HP. 400- TO 1,600-R.P.M. FIELDS-CONTROL TYPE MOTOR

range, to obtain slow speeds for machine adjustment or to minimize motor cost. Multi-voltage control may be combined with either armature or field control or both, to give a wide and uniform speed range. Field control is frequently provided on motors used with the Ward Leonard, variable-voltage system. With this arrangement a wide range can be obtained at minimum generator cost and with better speed-regulation characteristics than may be obtainable with voltage control alone. It should be noted that, where a speed range is divided between two control systems, the characteristics of each method prevail over its portion of the range. Thus where any method of armature voltage control is employed, a constant torque rating is obtained. Where motor-field control is employed, a constant horsepower rating is afforded.

The Wide Variation in Coal

BY V. G. LEACH*

How can two different mines, just a few miles apart and operating in the same geological seam, produce coals that vary materially in their characteristics and their relative value as a fuel? This question is entertained in the minds of almost every person connected with the coal industry, whether he be operator, salesman or buyer. To solve the problem, it is necessary to look back some three or four million years to an age known in geology as the "Carboniferous Period." Conditions at that time were ideal for the growth of vegetation. The air was so highly charged with carbon dioxide gas that animal life was confined to fish and amphibians.

*Combustion engineer, Bell & Zoller Coal Co.

The Middle West was then a vast and dismal swamp. Microscopic examinations of coal samples show that different types of vegetation predominated in various adjacent localities, which were probably separated by low hillocks or exposed strata of rock, the subsequent erosion of which caused different kinds and quantities of mineral impurities to be carried into the neighboring peat bogs, thus imparting to the resulting coal an ash that may be harmful or harmless, depending on the percentage in which the various impurities are present.

Of the original vegetations the intimate characteristics are, in a measure, preserved in the coal. For instance, one kind of wood will ignite quicker than another; so it is with coal. One kind of wood makes excellent charcoal, as to percentage of yield, hardness, structure, heat value and inflammability; so do some coals give a higher coke yield or better cell structure and density, as compared with another coal from the same locality. Professor Parr is responsible for a great deal of original research on characteristic differences of coal, as respecting the residual oxygen or "hydroxy" compounds which remain from the initial organic material after all the vicissitudes of decay and geological alteration have taken place. His investigations are virtually the first real step forward in the study of carbonization. It hinges mainly on the use of solvents, which separate the coal, without decomposition, into two portions, one of which has strong coking and the other non-coking properties.

PHENOL INDICATES DETERIORATION

Regarding this, J. F. Kohout, of the Commercial Testing and Engineering Company, says: "The amount of matter soluble in phenol, or carbonic acid, is a useful index of the degree of deterioration of coal during storage. The amount of extract is first determined on a fresh sample of coal, from the same mine and seam from which the stored coal was shipped, and then on the coal in question. The decrease in the amount of extract is a good measure of the degradation of the coal. In one instance where this was investigated, the amount of extract dropped from 28 to 17, or about 39 per cent. When this weathered coal was fired in the plant, the economy figures showed a loss of about 42 per cent, verifying closely the loss indicated by the phenol extraction determination."

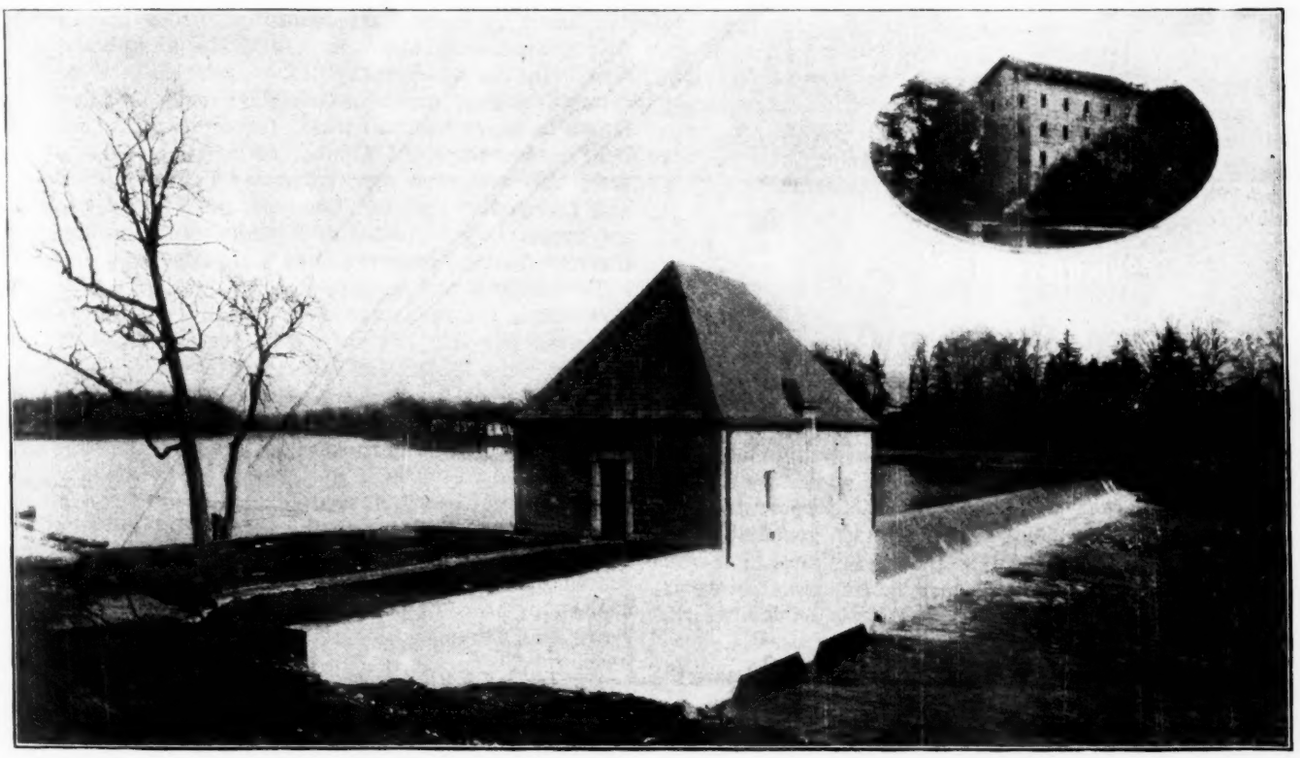
One of the most important characteristics of a coal is the ease or the reluctance with which it delivers up its volatile constituents under the application of heat. One coal will virtually belch its volatile content, while another coal from the same neighborhood and from the same seam will, in the same furnace, release its volatile matter gradually and slowly. Thus is presented the mystifying phenomena of two coals that have the same percentage of volatile, one of which is smoky and sooty, while the other has no objectionable smoke or soot. The smoke and soot formation, of itself, is easily accounted for by chemistry and is a matter of mathematical certainty; the difference here mentioned, is merely the quality, which it is customary to vaguely describe as "a flashy coal" or "a coal with holding qualities."

The more closely one studies the intimate and intricate differences that beset this most important of all commodities, the stronger becomes the conviction that a great deal more care should be exercised in the choice of a coal and its utilization as a fuel.

Two-Unit Automatic Hydro-Electric Plant Installed on Site of Old Mill

By SAMUEL B. MOTT,
Manager, Northern Indiana Power Company

A TYPICAL example of a small automatic hydro-electric plant operating in conjunction with a steam plant is to be found in the new Holliday Station of the Northern Indiana Power Co., formerly known as the Noblesville Heat, Light & Power Co. Construction work on this plant was begun July 14, 1922, and the plant was completed and put in operation Jan. 15, 1923. The new station is on the White River, four and one-half miles northeast of Noblesville, Ind., near the site of the old Conner mill, erected in 1868.



POWER HOUSE IS CONSTRUCTED OF STONE AND THE DAM OF CONCRETE

In order that the water power might be utilized to the fullest advantage, preliminary investigations were started in May, 1915, to determine the flow. At that time a Geological Survey gage was installed just below the site of the dam and power house, and since then two readings have been taken each day on this gage. Flow readings were taken at various stages of the river, and from the data obtained, flow curves were made. Independent flow readings plotted in curved form checked exactly with the initial flow curves so that it was assumed that the flow data obtained were correct.

From these data it was possible to determine the number of units that should be installed and the proper size of units. Two Leffel wheels were selected, each designed to utilize 300 sec.-ft. at 9 ft. head, which is the average operating head. This decision was reached after careful study of the average flow over a five-year period, and it was found that two units of the size indicated would produce a greater number of kilowatt-hours per year than any other combination of sizes.

The two wheels will generate approximately 1,300,000 kw.-hr. per year. They are directly connected to General Electric generators, each being rated at 240 kva. and operating at 100 r.p.m. The switchboard and automatic equipment are designed to take full care of the operation of the plant without any attendance except for oiling, inspection and the raking of the trash racks. The automatic equipment will take the units off the line and will put them on, as the occasion may demand, more quickly than an operator and with much greater precision.

Two methods may be employed, one of which utilizes the stream flow and automatically controls the gate opening in such a way that the water is held at the crest of the dam. The other method is to operate a machine at full gate opening until the head is lowered to a predetermined point, when the unit is automatically stopped and stays off until the head water again rises nearly to the dam crest, when the machine is automatically brought into operation. This method of operation is pursued only when the flow is not sufficient to furnish enough water for operating at full capacity.

At times of medium water one machine will be in operation at full capacity, and the second unit will come

on and off as the water conditions permit. By manipulation of a double-throw switch either machine may be made the leading or the trailing unit. At extreme low water only one machine is operated part time, while the other is cut off the line entirely.

The dam and substructure of the power house are built of concrete and rest on a Niagara limestone foundation. They are thoroughly anchored to the stone by reason of the fact that a trench three or four feet deep was excavated in which to place the dam. The tailrace beneath the power house was excavated to a depth of seven feet. The power-house building is constructed of Indiana stone and covered with a slate roof, it being desired to build in a permanent manner and so that the upkeep cost would be at a minimum.

At this plant three-phase current at 4,800 volts is generated and transmitted to the steam plant at Noblesville, where it is transformed into 2,400 volt two-phase current, brought in to a separate panel on the steam-plant switchboard. On this panel there are an integrating wattmeter, a curve-drawing wattmeter and an integrating watt-hour meter. The hydro-electric plant is operated in parallel with the steam plant except on Sundays and the after part of each night, when the steam plant is shut down entirely. During these periods the voltage regulator at the water plant makes it possible to give satisfactory service.

Cutting Fuel Costs

By George F. Swetnam

In considering good furnace construction it is well to note that much of the efficiency of any furnace depends on three things: The furnace must be air-tight, so far as walls and floor are concerned; the facilities for heating the boiler must be good; and the design must be such that the greatest possible percentage of the combustible elements of the furnace gases shall be consumed before passing into the breeching and thence to the stack. The last is especially important since it goes a long way toward the elimination of smoke, which, besides being objectionable, contains combustible material that is wasted, and furthermore coats the heated surfaces with soot, a heat insulation many times as efficient as asbestos. A previous article dealt with soot blowers, yet it is not advisable to depend on them alone.

But to return to the subject of good furnace construction, an airtight furnace is almost as important as a steamtight boiler. If there are holes in the boiler setting the cold air rushes in through them, lowering the CO_2, cooling the stack gases (thereby reducing the draft) and keeping much fuel from being burned.

The outer casing of the furnace requires less attention than the lining. Suffice it to say that it should be solidly set up with a good quality of mortar. The work should be done neatly, as this leaves fewer crevices where deterioration may set in. A space about 2 in. deep, 4 or 5 in. high, and about 2 ft. long should be left in the inner layer of bricks for the lining to hold to. The whole casing should be allowed to stand for a week or two to set before the inner lining is applied.

For lining I prefer to use some one of the numerous kinds of plastic firebrick preparations rather than regular firebricks. The reason I prefer the plastics is that they leave a smooth, unbroken surface, such as is difficult to obtain in any other way, and on which there is no place for fire and clinkers to take hold.

These plastics come in large containers. Their manner of application is so simple that anyone can put them in. The plastic is supposed to be in the best condition when the container is opened. Take it out in large portions and apply it to the furnace walls from 5 to 9 in. thick, and pound it thoroughly into place. If it isn't well pounded, the job will not prove successful. Finally, go over the surface with a trowel until it is smooth like glass.

The treatment given in the foregoing is for the more accessible places. For other places, such as making baffles, the plastic is worked with water to a dough or a thick pouring consistency, and worked into place.

In making front arches, and other overhead work it is necessary to furnish some support for the plastic until it is baked enough to harden. This can be constructed easily by almost any engineer, and after being put in place and suitably stayed, the plastic is packed and hammered into the space above the support.

When back arches are to be built, they are usually first shaped with sheet iron, and the arch built over that. In the construction of back arches of return-tubular boilers, provision must be made to allow the boiler to move backward as it expands. This may be done in two ways. A number of layers of asbestos, or some asbestos rope may be placed between the boiler and the arch. I prefer, however, to have an angle of the proper length riveted to the back of the boiler, with the arch resting near the edge when the boiler is cold.

To vitrify a furnace lining such as described, build a slow fire in the furnace, too low to burn out the wooden supports, but still hot enough to dry the moisture out slowly. Keep this up for twelve hours or more and then maintain a hot fire for five hours or longer. The first time the fire is burnt out, it is advisable to keep the doors shut until the furnace is cool, as the cold air might crack the walls if it struck them too suddenly.

Good combustion is secured by doing two things. The first is the building in the furnace of walls, baffles, arches and columns, whose purpose is to deflect the heated gases so they will remain in the furnace long enough to be completely consumed. The second is by the use of various kinds of stokers or grates, with the idea of keeping the fire in the best possible condition, stirred up just enough to make it burn well, and with just enough coal added to produce the desired amount of steam from the boilers.

Stokers are made with a fair degree of care, and as they are quite expensive they are usually carefully selected, but the following are a few of the characteristics a good grate should possess:

1. It should have ample facilities for plenty of air to be admitted to the fire through the bottom of the grate. This insures better combustion than if dampers in the furnace doors must be opened to secure the proper amount of air. Some engineers favor an air supply above the grate. I do not.

2. The kicker bars should be so arranged that the fire may be stirred or pushed back without giving coal an opportunity to fall through. Moreover, the kicking action should be sufficient to break up the fire and allow the correct amount of air to reach all parts of it.

3. The dumping bars should be so arranged that the ashes are removed with the least possible waste of good coal.

4. The motions should all be independent of one another, and if there are two or more sections to the grate they should be capable of being operated separately.

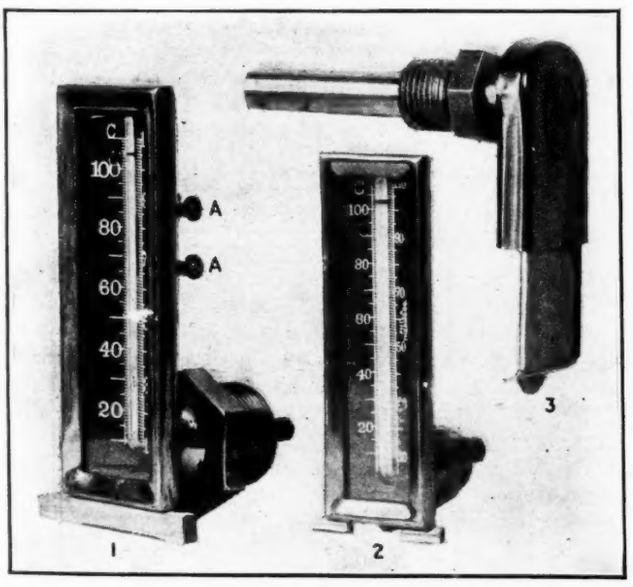
Obtaining an Indication of Transformer Temperatures

Measurements by Thermometers Placed in the Oil—Difference in Temperature Between the Oil and Windings—Use of Heating Coils for Determining the Winding Temperature

By J. B. GIBBS
Transformer Engineer, Westinghouse Electric and Manufacturing Company

IT IS frequently desirable to know how hot a transformer is running so as to tell whether more load can be added to it or whether a part of the present load should be removed. The obvious way to test this is to put a thermometer into the hottest part of the oil. This plan is much used, especially with small and medium-sized transformers. Figs. 1 and 2 show thermometers that are made to screw into a hole in the tank near the surface of the oil. The one shown in Fig. 1 has two binding posts *A*, which are for connection to an alarm circuit, while Fig. 2 shows a plain indicating type. When the oil reaches a dangerous temperature, the mercury in the thermometer, Fig. 1, closes the circuit and rings a bell.

In many cases, however, a simple thermometer is not satisfactory, either because it is not convenient to read or because it does not show the true temperature of the copper accurately enough. The first reason applies, for example, to distribution transformers



FIGS. 1 TO 3—DEVICES FOR INDICATING TEMPERATURE OF TRANSFORMERS

Fig. 1—Thermometer with connections for ringing an alarm. Fig. 2—Plain thermometer for connecting into the side of the transformer case. Fig. 3—Temperature indicator operated by a bi-metallic strip.

mounted on poles, and the second reason to large power transformers.

Several devices have been developed to indicate the temperature of distribution transformers, one of which is shown in Fig. 3. A hollow plug is screwed into the transformer case, so that its end projects into the oil. This plug carries a bimetallic strip which, when cold, supports a small semaphore within the indicator case at the end of the plug. When the bimetallic strip reaches a certain temperature, it releases a trigger and

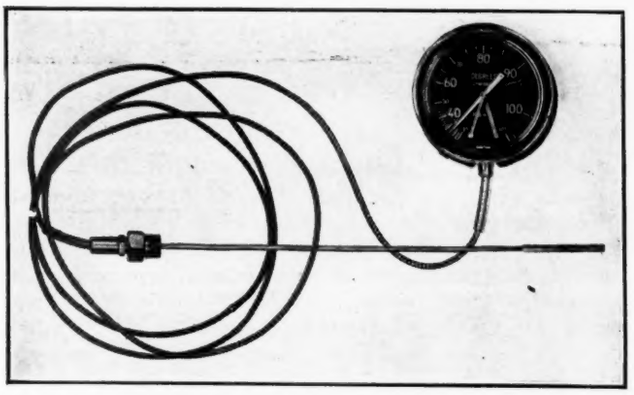


FIG. 4—DIAL-TYPE THERMOMETER AND BULB FOR USE WITH HEATING COIL

allows the semaphore to drop into sight. The semaphore is painted a bright color and is large enough to be easily visible from the ground. A patrolman can thus tell at a glance whether the transformer has exceeded the temperature for which the device was set.

In setting this device the difference in temperature between the copper and the oil must be allowed for. The assumption usually made is 10 deg. C. between the oil at the top and the oil at the bottom, 15 deg. C. between the hot oil at the top and the average copper temperature, and 10 deg. C. between the average copper and the hottest spot. The latter is the figure given in the A.I.E.E. Standardization Rules, and the other temperature differences represent average operating conditions for distribution transformers. The semaphore should be set to drop when the hottest spot in the winding reaches 105 deg. C.

105 — 10 = 95 deg. average copper temperature.
95 — 15 = 80 deg. temperature of hot oil at the top of the tank.
80 — 10 = 70 deg. temperature of oil at the bottom of the tank.

In deciding on the setting of the indicator, the type of load must be taken into account. High peaks in the load curve cause higher temperature gradients between the oil and the copper than normal loads.

In large power transformers such devices as those already described are not satisfactory, because the temperature of the copper may differ considerably from the temperature of the oil. The large volume of oil in such transformers may be heated very little, for example, by a heavy overload of short duration, while the copper may reach a dangerous temperature. Several

schemes are in use to show the actual copper temperature in such transformers.

A small resistance coil is sometimes inserted between turns of the transformer windings. As the transformer winding is heated, the resistance of this coil changes, and its resistance, therefore, serves as a measure of the temperature of the winding. This resistance coil cannot be insulated for the voltage of the transformer,

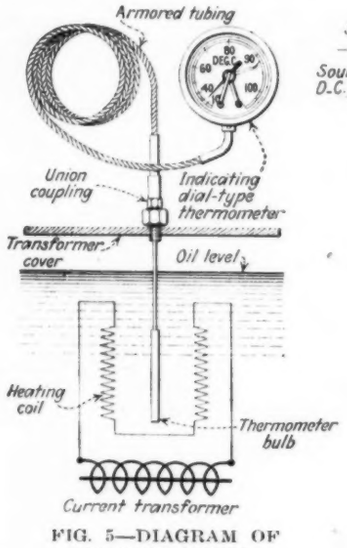


FIG. 5—DIAGRAM OF THERMOMETER CONNECTIONS

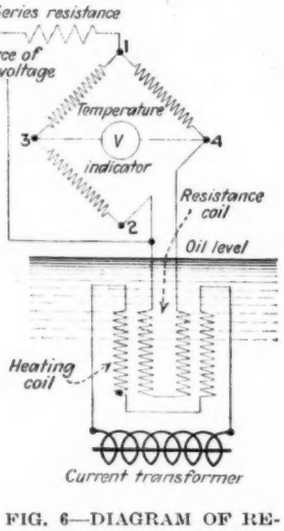


FIG. 6—DIAGRAM OF RESISTANCE-COIL CONNECTIONS

since such an amount of insulation would not only make it impossible to insert it in the transformer winding, but also blanket it so heavily that its temperature might not follow the winding temperature any more closely than the oil does. It would also be extremely dangerous, without insulating the coil for the full voltage of the winding, to bring its leads to the measuring instrument. It is, therefore, necessary to insert an insulating transformer between the embedded resistance coil and the measuring system. The change in the resistance to the coil is then measured on the low-voltage side of the insulating transformer by a bridge arrangement, and the result is read in degrees.

Creating an Artificial Hot Spot

Another method is to create an "artificial hot spot" by means of a special heating coil and a small current transformer and then measure the temperature with a thermometer or a resistance coil. The heating coil is of copper. It is worked at the same current density as the copper in the transformer windings and is located in the hottest part of the oil just below the surface. Its insulation is designed to give the same temperature gradient as the transformer windings have, and is supplied with current from a current transformer whose primary is in the main power circuit. The temperature inside the heating coil is, therefore, practically the same as the temperature of the winding for all conditions of load.

Current for the heating coil is usually supplied from a transformer of the ring type. This consists of a core built up of circular punchings on which the secondary coil of the transformer is wound. The primary consists of one lead of the power transformer which passes through the opening in the ring. This construction is simple, and it is easy to insulate the current transformer from the power circuit. In some cases where the current in the power transformer is too small to permit the satisfactory use of a ring-type transformer, a current transformer with a wound primary must be used.

The thermometer used with this arrangement is of the dial type and is shown in Fig. 4. The bulb is placed inside the heating coil and the dial is mounted on the outside of the tank. The dial is provided with contacts that can be set to give an alarm at any desired temperature. The dial is calibrated to read 10 deg. C. higher than the actual temperature inside the heating coil. It thus reads the true hot-spot temperature according to the A.I.E.E. rules. This arrangement is shown diagrammatically in Fig. 5.

Obtaining Record of Temperature

It is sometimes desired to have an indication of the temperature of the transformer at the switchboard or to make a continuous record of temperatures. In this case the thermometer is not used, but a small resistance coil is placed inside the heating coil. The resistance coil is connected to one arm of a Wheatstone bridge as in Fig. 6. The resistances for the bridge are chosen so that at approximately full-load temperature no current will flow through the voltmeter *V*. At other temperatures the current through the voltmeter bears a definite relation to the temperature of the resistance coil, and the voltmeter is, therefore, an indicator of the temperature. It is graduated in degrees centigrade so as to read 10 deg. hotter than the temperature inside the heating coil. The reading thus includes the standard 10 deg. hot-spot allowance.

When the heating coil is used, the general arrangement of parts is the same whether a thermometer or a

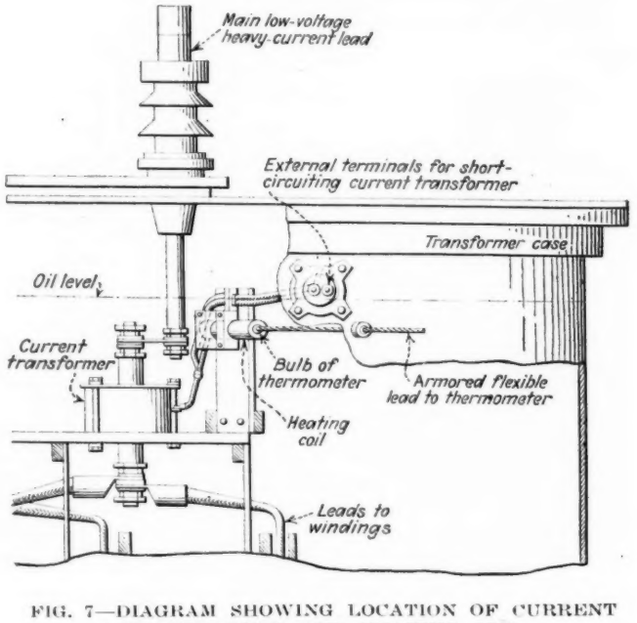


FIG. 7—DIAGRAM SHOWING LOCATION OF CURRENT TRANSFORMER AND HEATING COIL

resistance coil indicates the temperature. Fig. 7 is a diagram giving a typical arrangement. The current transformer is placed under oil and insulated from the circuit of the main transformer by a heavy insulating tube around the low-voltage stud. There is also an oil space between the tube and the current transformer. The heating coil is mounted near the current transformer and is connected to it, but has, of course, no connection to the main transformer.

EDITORIALS

F. R. LOW, EDITOR

Sheepskins and Civil Service

IS IT what a man knows or the process by which he learned it that qualifies him for service in the employ of the Government?

A recent announcement by the Civil Service Commission of a competition for the position of instrument designer stipulates that "applicants must be between twenty-five and forty-five years of age and must show that they have been graduated in engineering, preferably mechanical, from a recognized college or university."

We submit, as we have several times before regarding similar stipulations, that the material and essential qualification for an instrument designer is the ability to design instruments, that the Civil Service Commission is there to select from the list of those offering their service, those best qualified to design instruments, and that they cannot effectively discharge that function by delegating the first stage of the sorting process to a college faculty or board of regents.

Any applicant otherwise eligible should be free to demonstrate his fitness for such a position whether he acquired that fitness under corporate tutelage or by his own interested effort. No examining body has a right to rule the self-educated or special-tutor educated man out of such a contest.

Let us choose a man for what he is, and not by the route by which he came to be so.

Three Years' Progress

TWENTY-FIVE per cent increase in power-plant efficiency is a notable achievement in a three-year period. Yet this is the average increase in efficiency for public-utility power plants in the United States between 1919 and 1922, as indicated by recent data from the United States Geological Survey.

In 1919 there was used coal, or equivalent oil and natural gas, to the extent of approximately 39,000,000 tons for the production of 24,300,000 kilowatt-hours of electricity in these public-utility power plants. The average performance that year appears to have been about 620 kilowatt-hours per ton of coal or its equivalent. Based on an average heat value of. say, 13,000 B.t.u. per pound of coal, this would figure about eight per cent average over-all plant efficiency.

In 1922 a fraction of one per cent less fuel was used by these central-station plants; but in that year the output of electricity was 30,437,000 kilowatt-hours, or at the rate of 780 kilowatt-hours per ton of coal. Upon the same assumptions as before relative to the average heat value of the coal, this would represent an over-all efficiency of about ten per cent. Although this figure in itself leaves much to be desired, it is a notable improvement over that of three years previous, and the improvements in the stations now being built will tend further to increase this efficiency.

Central stations designed for operation at high load factor and large units are more and more superseding the smaller and more obsolete type of central station. This has been a large factor in the increase in efficiency. But, however one may account for it, it is notable and one on which the entire industry deserves congratulations. It is unfortunate that there are not available corresponding data for isolated power plants among the industries in order to ascertain if they have done as well in progress toward higher standards of operating efficiency. We hope they have.

The Proof of a Coal Is in Its Burning

ON ANOTHER page of this issue is a short article pointing out the wide variation that may exist in coal from different mines even in the same geological seam. Different coals of practically the same ultimate or proximate analyses have widely varying characteristics. That these facts are not generally realized is evidenced by the practice of the average coal buyer. If any comparisons are made, they are based mainly on the chemical analyses to the neglect of the burning characteristics. The buyer does not seem to realize that coals have "personalities." No one is in better position to become familiar with these differences than the fireman, but too frequently he is not consulted.

Chemical analyses are good as far as they go, but unfortunately they do not tell the whole story regarding the actual value of a coal for specific burning conditions. Other factors that would be of value to the purchaser of coal are the fusion temperature of the ash, the type of clinker formed, the physical differences exhibited during the coking period and the kind of hydrocarbons given off. A certain coal may give off volatile composed mainly of saturated hydrocarbons which burn clean and without deposits of soot, while from another coal considerable quantities of "tar fog" may be distilled, causing severe slagging, secondary combustion in the boiler, or excessive soot deposits and smoke. And as if this were not enough, it will be found that the same coal under different furnace temperatures due to variations in design, will behave differently.

In the furnace certain coals will swell up like popcorn, creating an ideal fuel bed that is fluffy and open, thus offering large burning surface and low fuel-bed resistance. Another coal may soften and fuse together in large cakes, usually resulting in a heavy ashpit loss and maximum fuel-bed resistance. Other coals may break apart and act much like red-hot sand. Heavy loss of draft through the dense fuel bed formed is to be anticipated as well as a large loss due to sifting in certain types of stoker.

It is evident, then, that there are other things to consider besides the ash and moisture content, the percentages of volatile and fixed carbon and the heat value. Theoretically, it is often claimed that the right way to buy coal is on the B.t.u. basis, paying in dollars and cents for a certain heat value and penalizing or

giving a bonus for variations. The producer does not favor this method, and the purchaser in numerous cases has found that it has not worked to his advantage. It is the same old story of other things to be considered. As has been aptly said, "When theory does not coincide with practice, then there is generally a shortage of theory." The Senegambian in the woodpile in this particular case is that the number of British thermal units per pound of coal, as shown by the calorimeter. usually does not indicate the heat units actually recoverable in the boiler plant.

While the analysis and the heat content of a fuel are valuable data to be used principally in checking shipments of coal, the final and best answer to the question at issue is to try out the coal in the plant.

Combustion Control Essential to High Efficiency

DEMAND for power was never before increasing at such a rate as it is today. Proof of this is found in the fact that during the last few months orders for more than one million kilowatts in large turbines have been placed with two of the large electrical manufacturing companies in this country. Not only are these demands increasing, but the sentiment is for cheaper power under more exacting requirements of service—this in the face of rising fuel, labor and material costs. So far the power-plant designing and operating engineers have been able to measure up to the requirements. How long they will do so depends on their ability to make improvements in the efficiency of steam power-plant equipment to counteract the rising costs of those elements entering into the price that must be paid for a unit of power.

The wide range that exists between the efficiency possible to obtain in a well designed and operated boiler plant and the average efficiency makes this field a promising one for increased economy. It is possible to get eighty per cent of the heat in the fuel into the water in the boiler, without economizers, but the average is probably nearer fifty per cent and a large percentage even below this figure. Of the many factors that affect boiler and furnace efficiency, control of combustion is one of the most important; not only because the products of combustion represent a source of the largest loss, but because it varies for each new condition. Adjustments may be made to give the highest efficiency, and in a short time conditions may change so that the quality of combustion will be decreased materially. If hand adjustment alone is depended on to regulate the operation of the boiler, the human element must be contended with, and at best it is not any too reliable. C. M. Smoot, in the leading article in this issue "Combustion Control for Boilers," says: "For a short run sufficient expert attention can be maintained on the boiler, but for every-day commercial operation few plants can afford the incidental expense or even maintain skilled operators in efficient control of combustion." Opinion among operators is as yet not crystallized as to the use of automatic regulation under all conditions, but the practice seems fairly general among the larger plants to let the automatic regulation take care of the base load and employ hand control for the peaks.

In other parts of the power plant automatic control has been developed to a high degree. Machine control can be developed to respond to the immediate requirements of the equipment to which it is attached, where an operator must wait for results before he knows what move to make. It is for this reason more than any other that automatic control would appear essential to sustained efficient combustion. How this should be obtained is a question that is not definitely decided, but whatever method is used, it is apparent that advantage should be taken of the stored heat in the boiler and setting to assist in supplying sudden increases in load. This is only recognizing the simple law that has been incorporated into all power machinery — sudden increases in load are accompanied by a reduction in speed to allow supplying some of the stored energy in the moving parts to the load and permit the source of power time to be adjusted to the new condition. Mr. Smoot gives some interesting arguments for taking advantage of this characteristic, and the reasons from which he derives his conclusions will be interesting to all concerned with this problem.

An Obstructive Policy

WHILE it is true that inadequate transportation is one of the big factors in the fuel problem, it is not so much an actual shortage of cars as it is the inefficient use of the cars already in service. Responsibility for this rests partly with the buying public and perhaps to a still larger extent with the railroads themselves.

Seasonal buying produces peaks in the transportation load, especially the fall demand, which is coincident with the movement of crops, and provision for adequate storage by consumers, stimulated by seasonal prices, would go far toward remedying this phase of the situation. But aside from this, the railroads consume about twenty-eight per cent of the coal hauled. They are practically without storage facilities and are in the habit of either holding coal for their own use in cars on sidings or, when necessity arises, of commandeering coal in transit. This tends greatly to aggravate the car situation.

As a remedy for this it appears likely that the President's Coal Commission will make strong recommendations that the railroads be compelled to provide storage facilities at their division points.

When it is considered that the railroads derive nearly forty per cent of their revenue from hauling coal, their present practice bears the stamp of poor business policy, for by releasing the cars their earning capacity would more than offset the expenditure involved in providing adequate storage.

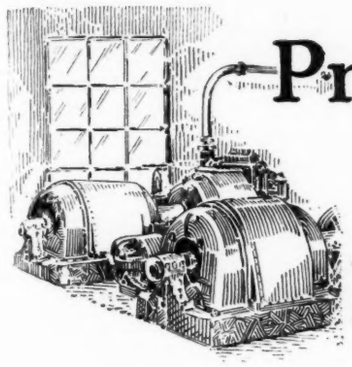
Warning to "Power" Subscribers

A MAN signing himself in at least one case "J. Wilson" and using a receipt blank bearing the name of the "Subscription Service Co. of Penna.," has been calling upon Eastern subscribers to *Power* recently and taking orders at the price of one dollar a year, collecting cash in advance. He either has, or claims to have, a list of *Power* readers.

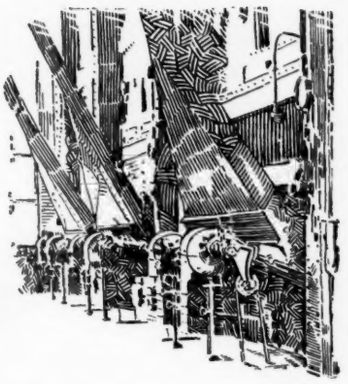
This man is a swindler. Don't give him a penny. Any list he may have has been obtained surreptitiously.

All bonafide McGraw-Hill Company salesmen are supplied with proper credentials, and money should be paid only to those who can establish their right to act for us.

Power readers will be doing us a favor and protecting their friends by passing this information on to others.



Practical Ideas *from* Practical Men



Experiences in an Ice Plant

Upon entering an ice plant as shift engineer last season, I found that the force had been having a lot of trouble in irregular freezing of the can ice. Upon investigation I found that no system was followed in pulling the ice. Whenever a can was found to be frozen, it was pulled, and usually this meant that several cans at one end of the brine tank were emptied of ice and filled with water in rapid succession, while at the other end the cans were only partly frozen. By starting at one corner of the tank and pulling every other can and then going back and pulling those left, we obtained a uniform temperature in the brine tank. As a result the trouble was overcome, freezing time was reduced and the plant operation much improved.

We also had some trouble with new piston-rod packing on the ice machine. The packing had a habit of breaking up and wearing out in a short time. By soaking the rings in graphite and oil for two or three days before using, it was found that the life of the packing was increased to an astonishing extent.

Denver, Colo. P. L. CONDEE.

Record of Instrument Charts in Stock Essential

The constantly growing tendency toward the use of recording instruments for showing plant conditions and operations makes it necessary for the engineer who does not want to be caught to take special steps to insure a full supply of charts at all times. Almost every different instrument requires a different chart, and with 10, 20 or more instruments one is likely to let the supply run out unless steps are taken to systematize the ordering of replacement supplies.

In our plant we have made up a list of all the various charts we use, giving in the list such information as the name and make of the instrument on which the chart is used, the address of the manufacturer, the serial number of the instrument, the number by which the charts should be ordered, and the quantity to be ordered at one time. In this way we have a quick and ready source of information. When word comes in that a new supply of charts is needed for the CO_2 recorder, for instance, it is not necessary to go out to the machine and get the information, or to write the purchasing agent to obtain information for us—we are in a position to send through our requisition in complete intelligible form, with the result that it goes through promptly. Any plant using a half dozen or more recording instruments of any kind, will find some simple scheme as this to be a time saver.

We have also found from experience that it often takes several weeks for chart orders to reach us, and we therefore maintain a reserve supply of 50 charts for each instrument. These are kept in separate envelopes in the office to tide us over in case the regular supply does not come in as soon as expected.

Philadelphia, Pa. M. A. SALLER.

Adjusting a Shaft Governor

A brother engineer requested me to assist him in his efforts to secure better regulation of the speed of his engine. As it was necessary for me to be in my own plant during the day, we had to attend to this extra job at night.

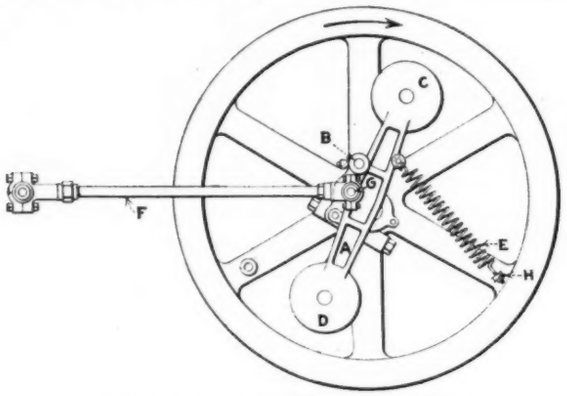
This plant is equipped with a high-speed engine that was originally controlled by a Rites type of governor, but for more than a year the speed had been partly regulated by manipulation of the throttle valve. As it varied from about 235 to 300 r.p.m. (more or less) it was unsatisfactory.

The engine was designed to run at 400 r.p.m, but that was considered too fast. This is a mistake, because an engine that is in good repair and properly adjusted, will run at the higher speed mentioned with good results. It is frequently assumed that less steam will be used if the speed is reduced, but this will not be realized in practice. It will not be necessary to admit steam so many times per minute, but the point of cut-off will be longer for the lower speed, hence no coal is saved by the change. This refers to lowering the speed of an engine that had been designed by the builders for a higher rate.

In order that the conditions may be fully understood, an illustration of the governor is presented. The weighted arm *A* is pivoted on the pin *B*, consequently as the wheel revolves in the direction indicated by the arrow, the tendency is for the wheel to move faster than the weights *C* and *D*. This tendency is counteracted by tension of the spring *E*, hence first one and then the other of these forces predominates, as the load on the engine varies. The valve rod *F* connects to the governor on the pin *G*. This moves around the center of the crankshaft (which is covered by the arm *A*) in circles of varying diameter, according to the load on the engine. With a heavy load *G* moves in a large circle, thus giving the cutoff valve full travel. When the load is lightened, *G* moves in smaller circles, thus admitting less steam to the cylinder. It is extremely sensitive, and will give perfect regulation when it is properly adjusted.

The speed may be varied within certain limits, by altering the tension on *E*. The trouble was caused by

this engineer's attempting to reduce the speed beyond the limits mentioned. He had loosened the nut *H* until all tension was removed from the spring when the engine was shut down. While it was running, a sudden change in the load would cause the arm *A* to pound on the stop provided for this purpose, and as this action soon



DETAILS OF SHAFT GOVERNOR

destroyed the rubber bumper that was intended to ease the blow, the pounding was dangerous.

The first move was to run the nut *H* down 1¼ in., giving a reasonable tension on the spring. Starting the engine showed that the speed was 400 r.p.m., which was too high. As there should always be at least a slight tension on the spring, even when at rest, it became apparent that more weight on *C* would give the desired reduction. As *C* moved near the arm of the wheel, thicker weights could not be used.

It should be remembered that these experiments were made at night, in a strange plant were the lighting equipment was poor, on account of frequently shutting down the engine. Furthermore, there was neither time nor facilities for doing machine work to secure any desired changes.

However, there were ten steel circular weights bolted at *C*, each 10 in. in diameter and weighing 2½ lb. each. These were removed, and as a large piece of sheet lead was available, ten circular weights, each 14 in. in diameter and weighing 4 lb. each, and 3 smaller ones weighing 2½ lb. each, were cut from it and bolted on at *C*. Thus by removing 25 lb. and substituting 47½ lb. the net weight was nearly doubled.

The engine was tested again with 40 lb. pressure, and the speed was practically 300 r.p.m. This was still too high, and no more weights were added at *C* until later on.

The speed was now nearly constant, although only a steady load was tried. As it was sure to be higher with more pressure on the boiler, further adjustment was necessary. This was accomplished by unscrewing *H* ¼ in., which reduced the speed to 280. Unscrewing it ⅛ in. more gave 255 revolutions. Increasing the pressure to 60 lb. raised the speed to 265, and when 80 lb. boiler pressure was carried, the speed of the engine was 275 r.p.m. Maintaining this pressure and starting some of the machinery reduced the speed to 270 r.p.m.

This action is given in detail in order that the matter may be clearly understood by readers who are not familiar with these principles. While this gave a steady speed for uniform conditions, a difference in the load gave too much variation in the speed. The general operation of the engine was much improved, as the pounding of the governor was eliminated.

Previous to this point no change had been attempted at *D*, but now 5 lb. weight was added here, and a further test was made with 80 lb. pressure and a friction load, giving 270 r.p.m. When the tension on the spring was reduced ⅛ in. more and 6½ lb. added at *C*, the regulation was perfect, under changes of both load and pressure, so long as the pressure was maintained high enough to carry the load.

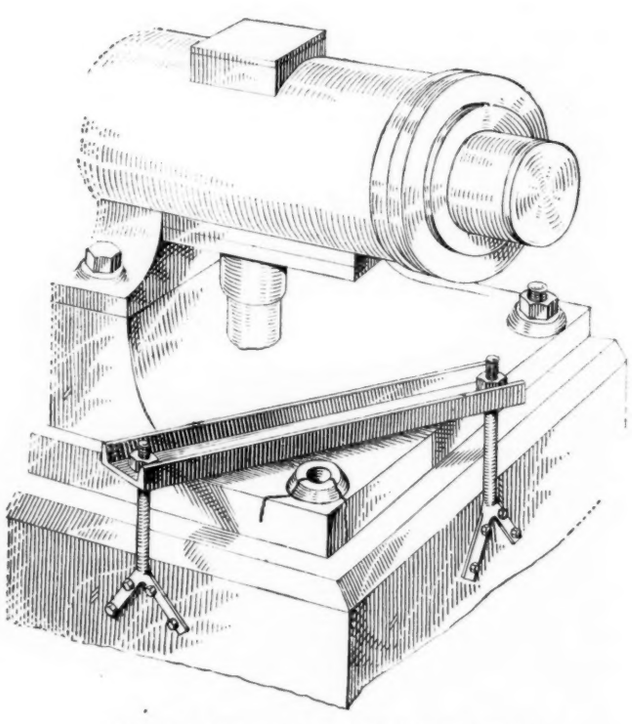
As 25 lb. was removed from *C* and 54 lb. added, the increased stress on the arm *A* may be more than the builder intended, but this engine has given satisfactory results for several months. W. H. WAKEMAN.

New Haven, Conn.

Repair of Broken Foundation Bolt of Oil Engine

After an oil engine was installed, it was found that the four holding-down or foundation bolts had a tendency to work loose. One, especially, seemed always insecure. Finally, one day the engine began leaping up and down, and investigation showed that this bolt had broken off close down to the concrete and had fractured the bedplate at the boss. We could not move the engine off of the foundation to place a new bolt, and it was practically impossible to operate it with but three bolts.

Upon the suggestion of an engineer a yoke was made at a welding shop from an old street-car brakebeam. This yoke was passed diagonally across the corner of



YOKE TAKES PLACE OF BROKEN BOLT

the base and was held down with two bolts, one at each end, to which V-shaped straps had been welded. These straps in turn were secured to the sides of the foundation by bolts sunk in lead. The yoke showed a little play but not enough to harm. The design of any engine should provide for more than four bolts or in all events bolts heavy enough to avoid breakage.

Bowling Green, Mo. COLIN K. LEE.

Lining Up Shafting Under Difficulties

On a job that I was supervising in my early days, it was required to put up a shaft indicated by the line *B* in the sketch, to be driven by a 24-in. belt from the shaft indicated by the line *A*. There was a solid brick wall between them with no opening nearer than the first floor, about one hundred feet below. The belt holes through the wall would not be cut out for some time, and I was anxious to get the *B* shaft erected, so that if there was any delay anywhere, it could not be charged to me.

The procedure I adopted for determining a line for the shaft *B* that would be parallel with shaft *A*, will be made plain by the sketch and a little explanation. Plumbing to the floor from one side of shaft *A* at two different points on the length of the shaft, I established two points on the floor. Setting a straight-edge to these points, I scratched a line on the floor, which was of course parallel with the shaft, and it made no difference for my purpose, whether it was the center of the shaft or not.

I then set the points of a trammel at nine feet apart, and with one trammel point set at the point *C*, I struck the arc *D*. Then with the trammel points set to twelve feet apart, and again from the point *C*, I struck the arc *E*, intersecting the line *A*. Then setting the trammel points to fifteen feet apart and setting one point at the intersection of the line *A* with the arc *E*, I struck the arc *F* intersecting the arc *D*, and setting the straight-edge through *C* and the intersection of the arcs *D* and *F*, I scratched a line *G* on the floor, which was at a right angle with the line *A*.

For the benefit of anyone not familiar with this method of erecting a right angle, I would say that it is based on the law of right-angled triangles, that the square root of the sum of the squares of the two sides equals the hypotenuse of a right-angled triangle. Thus the square of 9 is 81, and the square of 12 is 144. 81 plus 144 equals 225, and the square root of 225, or 15, is the length of the hypotenuse. Other lengths than nine feet, twelve feet and fifteen feet might have been used, such as three feet, four feet and five feet, or six feet, eight feet and ten feet, but the greater the dimension the more accurate the result, and the dimensions used fitted the space I had to work in.

The line *G* must now be transferred to the other side of the brick wall, and for this purpose I secured the targets *H* in the windows, as shown, and stretched the wire *J* on them. I then plumbed a vertical straight-edge at each of the two windows, where the targets were, with their edges facing the windows, and their lower ends on the line *G*, and then with a small wooden rod (with a pin driven in each end) as gage, the wire *J* was adjusted until it was parallel with *G*.

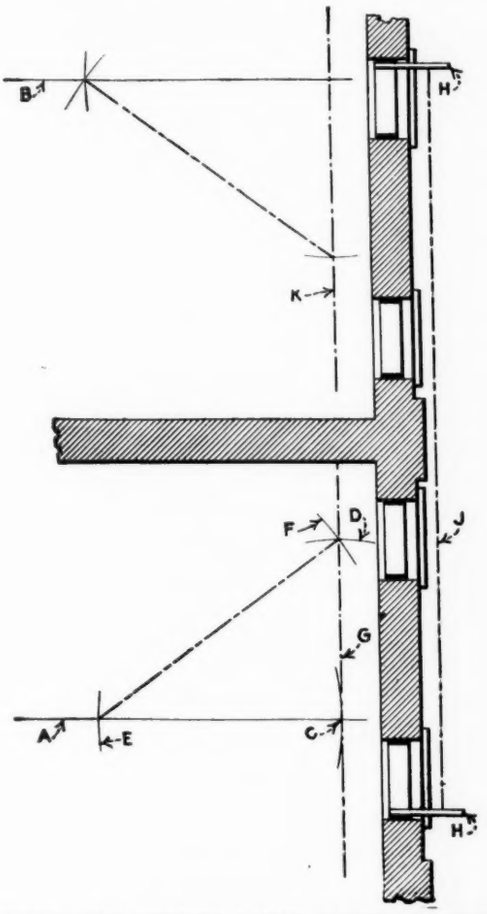
The reason for using straight-edges instead of plumb-lines to gage from, was that the straight-edges gave an unyielding surface for one end of the gage rod to bear against, while I was swinging the other end of the gage to find a contact with the wire, which simplified the operation considerably.

A pin driven in the end of a gage rod is a wonderful help in getting the right length, as it may be driven in a little or pulled out a little, as circumstances may require, and when the pinhead makes contact with a tight wire, you know at once, no matter how slight the contact.

The wire *J* was strung from one target to the other by tying a nut on one end of a chalk line, and a man leaning out of one of the target windows, with enough slack of the line to reach the next window, hanging free, would throw the nut and line to a man leaning out of the next window, who in turn would throw it to a man in the next window, and so on. The string was then used to pull the wire across.

With the wire *J* in place it was a simple matter to gage from the wire to two vertical straight-edges in the next room, and from the line *K* scratched on the floor, lay out the line *B* at a right angle to it by the method previously used. When the belt holes were cut through the wall and the belt placed on the pulleys, it tracked perfectly.

This job was one item in a pretty large job of power transmission, there being about three thousand feet



SHOWS HOW CENTER LINES WERE OBTAINED

of line shafting on various floors of a group of twelve-story buildings, with about fifteen miles of belting, beginning with a 54-in. belt in the engine room, that I gave the lines for, and only one belt of the lot failed to track perfectly when the plant was started. This belt ran off one edge of one pulley, about an inch, but tracked all right on the mating pulley. Shifting the pulley did no good, and checking over the lines showed them O.K.

By this time the bright streak that always shows up on the face of a crowned pulley, after it has been run a little while, indicating the high part of the crowning, began to show, and I saw what I had begun to suspect, that the crowning was off center. When this was corrected, the belt ran all right. ALONZO G. COLLINS.

Philadelphia, Pa.

Comments from Readers

Putting Alternators into Service After Excitation Has Been Lost

Referring to the inquiry by F. A. Ingalls in the Jan. 30 issue, I would say that the method used to restore service after the loss of excitation on the two turbo-generators was the most effective and quickest that could have been followed. This statement is based on the result of experiences and observations outlined in what follows.

Two 2,000-kw. waterwheel generators were left connected to a common bus at zero voltage after separating from a transmission line, with one unit on governor control, and the other on hand control, the generators operating at unequal speeds. As the field current was increased by building up the exciter-bus voltage, the speed of the generator on hand control increased until it was equal to that of the generator under governor control, and the generators pulled into synchronism with little interchange of current. The load, of course, could not build up, for the line switch was open.

In order to check the phase rotation of two 2,000-kw. generators, each generator, while operating at low speed under hand control, was excited from a common exciter bus, and as the phase rotation was correct, the generators pulled into step without the slightest difficulty.

A case where field excitation was lost, somewhat like the trouble related by Mr. Ingalls, occurred when, owing to the incorrect paralleling of exciters, the exciter bus voltage dropped to zero. The three 2,000-kw. generators in this station, which were operating in parallel with other plants forming part of a large transmission system, slightly increased in speed, dropping a portion of the load, and when, after an interval of about 50 sec., the exciter-bus voltage was restored, the generators pulled into synchronism without appreciable disturbance.

Three 10,000-kw. generators operating at rated speed under governor control have repeatedly been pulled into synchronism by simultaneously closing, by means of a master switch, their field breakers; in fact, on some systems trouble of an electrical nature is cleared by reducing the field excitation to zero for a brief interval, then increasing it to normal. In most operations of this nature the generators can be depended upon to return to synchronism without serious disturbance.

Attempts that have been made to pull two 20,000-kw. generators, driven by two waterwheels, each being under the control of a separate governor into synchronism, have not always been successful, largely because of hunting on the part of the governors. Generally speaking, those generators constructed with solid field poles, or amortisseur windings, will pull into synchronism more quickly than those not so constructed, and any difficulty experienced is likely to be due to differences in speed, assuming that the generators have the same number of poles, or to hunting of the governors. This last condition is obviously not present if only one governor is functioning on the units that are to be pulled into synchronism. Under average conditions the armature current of generators synchronized by building up the field current will rarely exceed 50 per cent of full-load value, and this is not objectionable; and the shocks imposed on generators synchronized in this manner are not likely to be as severe as those resulting from poor synchronizing at normal voltage. Even if the generators are protected by excess-current relays having settings as low as 1.5 times full-load current, the cross-currents are unlikely to be of sufficient magnitude to trip the circuit breakers when field current is applied.

In Mr. Ingalls' case, had the 4,000-kw. generator been cut out and service restored by increasing the voltage to normal on the 6,000-kw. generator, it is possible that this unit would be overloaded before the 4,000-kw. generator could be synchronized without taking a chance shot. Generally, after an interruption of this nature the load increases very rapidly, causing fluctuations in the frequency and voltage, making it difficult to synchronize, and if the 6,000-kw. unit became seriously overloaded, it might have been necessary to cut off the load, synchronizing at no lead and then permitting the load to build up. The possibility of these difficulties occurring was avoided, however, by following the method outlined by Mr. Ingalls.

In general, where one generator may not have sufficient capacity to produce properly the power that may be demanded before a second generator can be paralleled, two or more generators may be synchronized by connecting their field windings to a common bus and gradually increasing the voltage of this bus. If intelligently applied, this method may be used without risk to pull a number of alternating-current generators into synchronism when operating at approximately synchronous speeds.

RALPH BROWN.

Belden, Calif.

Bending Copper Pipe

A "filler" paragraph in a recent issue of *Power* having to do with the bending of copper pipes, seems to be somewhat obscure or misleading and invites something a little more explicit. One of the great advantages in the use of copper pipe is that it can be so easily bent to accommodate itself to all positions and that the fluid it conveys can flow in easy curves instead of with the jerky transitions which iron pipe fittings compel, and it would be well if it were more commonly used.

It is my experience that copper pipe in normal condition does not require to be annealed for bending. The rosin, of course, is used in the pipe to maintain its rotundity when bending. The pipe is plugged at the end nearest the place where the bend is to be made and melted rosin is poured in to fill that portion of the pipe completely. It must then be allowed to cool until the rosin becomes perfectly solid. The melting point of rosin varies somewhat, but is a little above the boiling point of water, say about 250 deg. F.

For bending the pipe, it is laid over a suitable block,

preferably with a semicircular groove just gripping the pipe on the sides. One end of the pipe being secured, force is applied to the other end sufficient to do the bending as required. It will be found that the pipe can be bent quite easily at the beginning, but that constantly increasing force will be required to continue the bending. Competent judgment, gained by some experience, can usually determine how far it is safe to go with the operation, but if judgment is not sufficiently assertive and if the attempt at bending is continued, the pipe will suddenly snap, often breaking right in two, and then it will be said that the pipe has become brittle and should have been annealed.

The correct explanation is very different from this. The bending of the pipe with the solid rosin inside tends to compress the rosin, which in the solid state is not very compressible. It is the resistance to compression which puts such a strain on the copper pipe and causes the breakage, and it is not because the copper has suddenly become brittle. The correct way is to bend the pipe as far as may be judged safe and then to heat it and liquefy the rosin and release. When the pipe has cooled and the rosin has solidified, it will be found that the pipe can be bent with comparative ease again.

Bronx, N. Y. FRANK RICHARDS.

New Graphical Methods Needed

With reference to your editorial on "New Graphical Methods Needed," in the Jan. 2 issue, the illustration shows a co-linear chart that I have used on the production of several hundred centrifugal pumps. This chart is a short cut for finding the specific speed of a pump, which is a method of calculating a pump so that it will fit a given set of conditions to the best possible advantage. A full explanation of the theory is given in textbooks on centrifugal pumps, and it is fundamentally the same as applied to water turbines or steam turbines.

The equation is usually given:

$$N_s = N \frac{\sqrt{Q}}{\sqrt[4]{(k\,H)^3}}$$

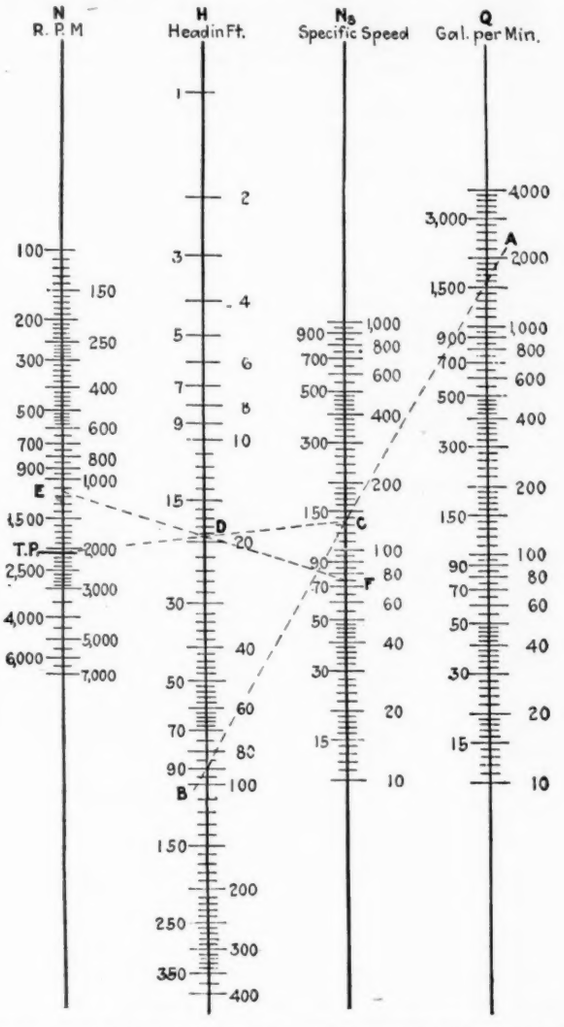
in which Q = gallons per minute, N = actual revolutions per minute, H = head in feet, and N_s = specific speed.

This chart takes the complicated formula, which is a laborious thing to use, and transforms it into the simplest terms. This not only saves time, but also there is less chance for error. It also makes it possible to get any one quantity if the other three are given. This is done without changing any intricate mathematical terms, which usually introduces the possibilities of further errors.

An example will illustrate the use of the chart. Suppose it is desired to pump 1,600 gal. per min. against 90 ft. head using direct drive to a motor having a speed of 1,150 r.p.m. What will be the specific speed?

The four quantities marked N, H, N_s and Q on the chart are the same as used in the equation given. Draw the line AB connecting the point representing 1,600 gal. per min. with the point representing 90 ft. head. This intersects the specific speed line at the point C. Now draw a straight line from C to the point marked $T.P.$ on the speed line. This point is a constant and is used for all problems. Now from the point E, representing the 1,150 r.p.m., draw a line through D intersecting the specific speed line at F, which gives the resulting specific speed as 76. Now by comparing this value with previous tests on the pump or on similar pumps, the efficiency expected can be accurately determined.

Had any other of the four quantities been required, the solution would have been the same, except that it would have proceeded in a different order according to what quantities are given. For example, it might be known that a certain pump does its best when a certain specific speed is used. The problem would then be to find what actual speed N would be required to obtain this specific speed and also the required head and capacity.



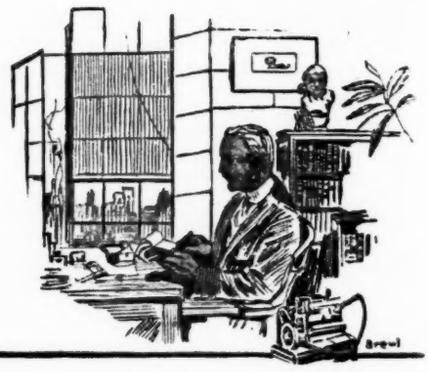
A CO-LINEAR CHART FOR DETERMINING VALUES USED IN CENTRIFUGAL-PUMP DESIGN

Another use of this chart is to find the point best suited to multi-stage pumps. Sometimes the designer is confined to a certain capacity, head and actual speed, and the chart may show too low a specific speed for efficient operation. In that case a multi-stage pump can be used, breaking the head into smaller parts and greatly reducing the value of the specific speed.

The value of the specific speed should not be confused with the efficiency of the pump, toward which it bears an important relation. This relation can be found only by testing the pump. Almost any pump will give the best results when the conditions are such that the specific speed is between 70 and 150.

Columbus, Ohio. RUSSELL K. ANNIS.

QUESTIONS AND ANSWERS



Higher Water Shown After Blowing Glass Gage

What causes a glass gage to indicate a higher water level after the water column has been blown down? L. T.

By blowing down, the water is replaced by water that is hotter and of less density, with the result that a higher column of water is sustained by the pressure of the water in the boiler, showing higher level than normally.

Burning of Boiler Heating Surfaces Below Water Line

Can overheating or burning of boiler-heating surfaces occur when the parts are below the water line in the boiler? J. L. R.

When steam bubbles "pocket" or adhere to the hot tubes or plates where they are formed, the heat of the fire is not promptly transmitted to the body of water in the boiler and overheating and burning of the metal results. This condition may result from excessive forcing of almost any type of boiler and is especially likely to occur with vertical tubes and furnace sheets of internally fired boilers.

Thermometers on Cooling Systems

Our air compressor is supposed to handle 450 cu.ft. of free air per minute. The cooling water is circulated by an air jet connected with a water tank 8 ft. above the compressor. Should there not be thermometers in the water circulating pipes for indicating the temperatures, and also as a warning of undue heating of the cooling water from leakage or other causes? L. E. H.

Thermometers should be set in the supply and discharge lines of the water-jacket cooling system so the cooling conditions may be known at a glance from the difference of temperatures. Many operators of air compressors are obliged to rely on feeling the warmth of the pipes. This, however, is an uncertain and unscientific method of determining the effectiveness of a cooling system that is inexact both for comparing conditions that may exist at different times in the same plant and for making comparisons with other installations.

Required Size of Water Pipe Line

What size of iron pipe 1,000 ft. long would be required for driving an 8-volt 5-ampere electric generator by a waterwheel supplied from a spring at an elevation of 30 ft. above the waterwheel? A. G. W.

The combined efficiency of a water-motor and generator of the size required probably would not be over 20 per cent, and the motor would have to be supplied with sufficient water under sufficient head to develop $(8 \times 5) \div 0.20 \times 44.24 = 8{,}848$ foot-pounds per minute. Reserving 15 ft. of head for operation of the water motor would require the discharge of $8{,}848 \div 15 = 589.8$ lb., or about 70 gallons of water per minute, which would be about the quantity discharged by a 3-in. pipe 1,000 ft. long, with 15 ft. loss of head by friction. With a 2½-in. or smaller pipe, the loss of head from friction would be so great that the quantity of water required for the remaining head would be in excess of the delivery capacity of the pipe.

Loss From Elevated Brine Cooler

If in a refrigerating plant the ammonia compressor and condenser and liquid receiver are in the basement of a building, and the liquid line is connected to a brine cooler on the roof, 250 ft. above, would the arrangement increase the head pressure any considerable amount or decrease the pressure of the expansion valve? C. L.

The location of the cooler 250 ft. above the receiver would not alter the condenser or head pressure, but will lower the pressure at the expansion valve. Elevation of the brine tank would not change the net effect on the plant operation, as may be understood by an example.

Assume the condenser pressure is 160 lb. gage, which corresponds to a condensing temperature of 87.7 deg. F., and that the suction or coil pressure is 15 lb. gage corresponding to a boiling temperature of 0 deg. F.

At 87.7 deg. F. a cubic foot of liquid ammonia weighs approximately 36.9 lb. The pressure exerted by liquid ammonia per foot of height is then 0.256 lb. per sq.in. and a 250 ft. riser pipe would exert a counter-pressure on the receiver of $250 \times 0.256 = 64$ lb. per sq.in.

With a receiver pressure of 160 lb. gage the net pressure at the expansion valve becomes $160 - 64 = 96$ lb. per sq.in. With a coil or suction pressure of 15 lb. gage, and a pressure at the expansion valve of 160 lb. gage, the net refrigerating effect per pound of ammonia is

$$R = H_2 - h_1$$

where

R = Refrigerating effect in B.t.u. per pound;

H_2 = Total heat in one pound of ammonia at 15 lb. gage = 611.4 B.t.u;

h_1 = Heat of the liquid at 160 lb. gage = 141.2 B.t.u.;

or

$$R = 611.4 - 141.2 = 470.2 \text{ B.t.u.}$$

In the case in question the pressure at the expansion valve is not equal to the head pressure of 160 lb. gage, but is only 96 lb. gage. As the liquid ammonia rises up along the pipe, the decrease in pressure causes part of the liquid to flash into vapor and also drop in temperature. Assuming no absorption of heat through the pip-

ing the ammonia mixture contains as much heat when it reaches the expansion valve as it had at the receiver; namely, 141.2 B.t.u. per pound.

However, at 96 lb. gage, a pound of ammonia liquid has 111.2 B.t.u. and the excess, 141.2 — 111.2 = 30 B.t.u., causes part of the ammonia to vaporize. Since at 96 lb. gage a pound of liquid ammonia requires the addition of 517 B.t.u. to vaporize, this 30 B.t.u. vaporizes 0.06 lb. of ammonia. This means that of each pound of ammonia reaching the expansion valve, only 94 per cent is liquid and 6 per cent is vapor.

But in passing through the expansion valve and being reduced in pressure from 160 lb. to 15 lb. gage, 18 per cent of the liquid flashes into vapor. If the 6 per cent of the liquid flashes as it passes up along the pipe, there is still 12 per cent which vaporizes as it passes the expansion valve. Consequently, as regards the plant efficiency, the location of the cooler on the roof is without influence. However, 6 per cent of the ammonia reaches the valve at 96 lb. pressure as vapor, and since one pound of ammonia vapor at 96 lb. gage has a volume of 2.655 cu.ft., there is $0.06 \times 2.655 = 0.159$ cu.ft. A pound of ammonia liquid has a volume of 0.027 cu.ft., and it is obvious that one pound of the mixture has a volume of $0.027 \times 0.94 + 0.159 = 0.184$ cu.ft., or approximately seven times the volume of a pound of liquid. The expansion valve must be large enough to accommodate this increased volume.

Properties of Electric Circuits

What is the meaning of the terms admittance and susceptance as applied to alternating-current circuits? M. R.

With regard to the flow of electricity all substance may be considered as possessing two properties—first, the property that opposes the flow of an electric current, called resistance and expressed in ohms; second, the property that allows the flow of, or conducts an electric current, called conductance. In any material if the resistance is high the conductance must be low, or conversely, if the resistance is low the conductance must be high. The relation of the resistance to conductance in any circuit is expressed as, if R represents the resistance of the circuit the conductance is represented by $\frac{1}{R}$; in other words, if the resistance is 20 ohms, the conductance is equal to $\frac{1}{20}$.

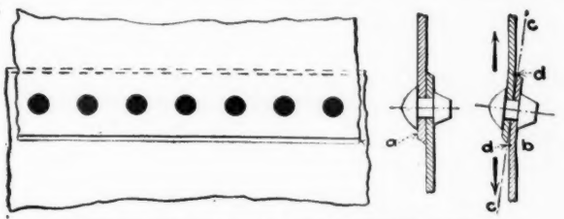
In a direct-current circuit of given voltage the value of the current in amperes is determined by the ohmic resistance of the circuit. In an alternating-current circuit of given voltage, the current is limited not alone by the ohmic resistance of the circuit, but also by another factor called reactance. This reactance is due to the varying magnetic field of the circuit generating a voltage which opposes the applied voltage and is called inductance and also the circuit acts as a condenser, this property being called capacity. Except in long-distance high-voltage transmission lines the capacity or condenser effect is low, therefore will not be given further consideration here.

The inductive reactance of a circuit may be expressed in ohms just as the resistance of the circuit is, and is represented by X, where the resistance is represented by R. The ohmic resistance and inductive reactance bear a relation to each other that makes their effective value Z, which is called impedance, equal to the square root of the sum of the squares of the ohmic resistance and the inductive reactance in ohms, or $Z = \sqrt{R^2 + X^2}$. If $R = 16$ ohms and $X = 12$ ohms, then impedance $Z = \sqrt{16^2 + 12^2} = 20$ ohms. The admittance of the circuit is 1 divided by the impedance or, *admittance* $= \frac{1}{\textit{impedance}} = \frac{1}{Z} = \frac{1}{20}$ and the susceptance equals 1 divided by the reactance, or *susceptance* $= \frac{1}{\textit{reactance}} = \frac{1}{X} = \frac{1}{12}$. In other words, where conductance is the reciprocal of ohmic resistance, admittance is the reciprocal of impedance in ohms, and susceptance is the reciprocal of reactance is ohms. The latter two apply to alternating-current circuits only.

Merit of Lap Joints

Why are lap joints considered to be inferior for longitudinal joints of boiler shells and sufficient for circular seams? E. N. C.

A plain lap joint, such as illustrated, consists merely of overlapping plates held together by one row of rivets. The stress pulling across the joint has a tendency to



DISTORTION OF LAP JOINT FROM STRESS

draw the plates in line, and the joint, originally as at *a*, assumes or tends to assume, the distorted form shown at *b*. This action may be more or less relieved by bending the plates before they are riveted, but the rivets are exposed to considerable tensile as well as shearing stress, and the bending action is likely to open the laps along the line *cc* with leakage of the joint, or cracks in the plate may occur at *d* where the distortion is most severe. There is the same tendency to distortion with double-riveted lap joints, although the distortion is not so severe when the plates are bent before riveting, as the greater width of the lap makes preliminary alignment of the plates possible with easier bends. So many boiler failures have been traced to the cracks and excessive stresses induced by bending of the plates at the laps that, in good practice, lap joints are considered to be unfit for longitudinal seams of cylindrical shells that are subjected to high pressures. In a butt and double-strap joint, the plates to be joined lie in line with one another, the joint is built up nearly symmetrical with inside and outside cover plates, most of the rivets are in double shear, and with the plates properly curved before riveting, there is little tendency to distort and crack. However, the single-riveted lap joint is suitable for girth seams in cylindrical shells, as the tension is low and, from the fact that such joints form part of a circular shell, their rigidity is enhanced and there is much less tendency to distort the plates than in longitudinal lap joints.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—EDITOR.]

Easy Lessons in Engineering

Square Roots and Cube Roots—A Simple Method

Engineering computations frequently require the extraction of square roots and less often of cube roots. The ordinary methods taught in arithmetic are hard to understand and quickly forgotten. Those shown here may not meet the approval of the skilled mathematician, but they are easy to understand and remember and for that reason may be helpful to such practical engineers as have difficulty in remembering the ordinary arithmetical methods.

Suppose you want to find the square root of 57.25. Take a sheet of paper and make two columns, the first for numbers or "roots" and the second for their squares. Table I shows the columns as they will appear when all filled out. The letters at the left are put in for reference in the explanation.

The method to be used is really that of "try and fit" intelligently directed. The idea is to put down pairs of numbers, of which one is larger and one smaller than the root to be found, and then "close in" on the correct answer.

Start by writing ? for the root to be found and 57.25 for its square. Then, using numbers of a single digit, put down 8, with its square of 64, and 7 with its square of 49. Evidently, the answer lies between 7 and 8. Split the difference and try 7.5. Its square at *D* is seen to be 56.25, which is not far below 57.25, the correct value.

It seems probable that 7.6 squared will exceed 57.25. A trial, as at *E*, gives 57.76. Then the correct value is between *D* and *E* and a little nearer *E*, so try 7.56 for the next approximation. This gives 57.154 (at *F*). As this is low but very close, try 5.57 giving 57.305 at *G*. Then the answer must lie between 7.56 and 7.57, and is nearer 7.57. If three places of figures is close enough stop here, writing 3.57 for the final answer. If not, it may be rather tiresome to proceed in the same manner with numbers of four or more places. To save time at this point consider that you have a table as follows:

	Number	Squares
F ..	7.56 ..	57.154
G ..	7.57 ..	57.305

To find the number whose square is 57.25, it is only necessary to "interpolate" or find a number that is located the same fraction of the distance from 7.56 to 7.57 as 57.25 is located from 57.154 to 57.305. From 57.154 to 57.305 is 0.151, while from 57.154 to 57.25 is 0.096. Dividing 0.096 by 0.151 we get 0.64, which shows that the number is 64 hundredths of the distance from 7.56 to 7.57. Then the square root should be 7.5664. This, squared, gives 57.250 which shows that the answer is sufficiently close.

Table II shows how the same method may be used in getting the cube root of 462.4. The only difference is that in this case more labor is required in making the trial computations.

Start as before by making two columns, one for numbers, and one for their cubes. In the first line put down ? for the number and 462.4 for its cube. In *B* the cube of 10 is 1000. The cube of 5 is 125. So the desired number lies between 5 and 10. Split the difference roughly and try 7. Its cube, 343, is low, so the answer must lie between 7 and 10. Try 8; its cube is 512, so the number lies between 7 and 8. Proceed in similar fashion with two digits and then with three

TABLE I
Example of Square Root

	Number	Square
A	?	57.25
B	8	64
C	7	49
D	7.5	56.25
E	7.6	57.76
F	7.56	57.154
G	7.57	57.305
H	7.5664	57.250

TABLE II
Example of Cube Root

	Number	Cube
A	?	462.4
B	10	1,000
C	5	125
D	7	343
E	8	512
F	7.6	438.98
G	7.7	456.53
H	7.8	474.55
I	7.73	461.89
J	7.74	463.68
K	7.7328	462.39

until *I* and *J* are reached. The number then lies between 7.73 and 7.74 and is found by "interpolation" (as explained in the previous example) to be 7.7328. Cubing this number as a check, we get 462.39 which shows that the root is sufficiently close.

When taking square roots it is convenient to have the number lie between 1 and 100. If the number lies above or below these limits, the decimal point may be shifted two places at a time and then moved back on the answer half that number of places.

For example, before taking the square root of 0.005725 you may move the decimal point 4 places to the *right*, giving 57.25. The square root of this is 7.5664. To get the square root of the original number move the point 2 (half of four) places back to the *left* giving 0.075664.

Similarly, before taking a cube root it is convenient, though not necessary, to change the number to one between 1 and 1,000 by shifting the decimal point 3, 6 or 9, etc., places. When the root is obtained, move the point one-third that number of places in the opposite direction. For example, to get the cube root of 462,400 you may move the point 3 places to the *left*, giving 462.400, whose cube root is 7.7328. Then move the point in this root 1 (one-third of three) place to the *right* to get 77.328, the final answer.

There are other and quicker methods of finding square and cube roots. Among these are tables, logarithms and slide rules. These methods, which should be used whenever the necessary tables or slide rules are at hand, will be explained in later articles.

In presenting the foregoing there is no intention of discrediting the ordinary methods of arithmetic. Anyone who remembers the latter and can use them without confusion is well fixed, and will probably gain nothing by changing to the procedure here shown.

Dust Prevention in Pulverized-Fuel Systems

National Fire Protection Association Committee Recommends Regulations for Installation and Operation of Pulverized-Fuel Equipment

THE subcommittee report on "Proposed Regulations for the Installation of Pulverized-Fuel Systems" has been approved by the main committee on dust-explosion hazards of the National Fire Protection Association. This code is to be recommended to the annual meeting of the Association at Chicago in May for tentative adoption. In the meantime a meeting of the committee is being held this week (March 5 and 6) at the Hotel Statler, Buffalo, to consider any further suggestions that may be advanced regarding the regulations in their present form.

Anyone interested in these regulations and desiring to suggest additions or changes should communicate, prior to the May meeting, with David J. Price, chairman, United States Bureau of Chemistry, Washington, D. C., The regulations proposed are as follows:

PROPOSED REGULATIONS FOR THE INSTALLATION OF PULVERIZED-FUEL SYSTEMS

Pulverized-fuel systems are of various types; all involve the hazard incident to the creation and possible liberation of combustible dusts. In general they may be arranged in three classes as follows:

Class A: Indirect, or those in which the fuel is intimately mixed with air only at the point or points where used and involving storage bins at points of consumption.

Class B: Direct, or those in which the pulverized fuel is fed to a fan by which it is blown as a combustible mixture through large pipes to furnaces or other points of combustion. In the case of circulating systems of this class the unused fuel is returned to the initial point to again be blown through the line.

Unit System: Those in which the fuel is pulverized at or near the point or points of use and delivered directly from the pulverizer into the furnace by means of fan or blower, which may be an integral part of the apparatus, the air being admitted in the apparatus or in conjunction with the fuel.

Installation of pulverized-fuel systems should be under the supervision of engineers qualified by experience in the design, construction and operation of such equipments.

Note: The term "approved," shall be interpreted as by the Inspection Department having jurisdiction. The terms "adequately," "effective," and "securely" shall be interpreted as conditions subject to the approval of such Inspection Department.

GENERAL REGULATIONS—

Class A and Class B Systems

1. Location—The processes of crushing, drying and pulverizing fuel shall be accomplished in a separate building used for no other purpose. This building shall preferably be detached, but where this is not practicable, it shall be separated by a blank masonry or concrete fire wall containing no openings other than those necessary for the passing of pipes and shafting. Every process or operation involving the use of or consumption of pulverized fuel should preferably be carried on in a separate room, or on a separate floor used for no other purpose, and cut off horizontally and vertically in a standard manner.

2. Construction—(a) The building containing pulverizing equipment shall be constructed of incombustible materials and specially designed (1) to secure minimum lodgment of dust and (2) to relieve the force of an explosion through its roof and walls without damage to its frame.

Note: See Section 29, Building Code of the National Board of Fire Underwriters for fire-wall construction requirements; also National Fire Protection Association regulations for the protection of openings in walls and partitions against fire.

(b) The frame shall be preferably of steel with light non-bearing walls (except fire walls), constructed of such materials as stucco on metal lath, tile, metal or other similar incombustible material, and with roof of monitor or gable type, and all secured in such a manner as to give way readily under pressure of explosion.

(c) In order to prevent accumulations of dust, the design of the building shall be such and the structural members so shaped and assembled as to present the least possible extent of surface on which dust can lodge. In the existing building where this feature cannot be provided, the trusses may be inclosed and the roof and wall members covered with metal lath and plaster ½ to ⅝ in. thick, finished smooth.

(d) In order that the venting of explosions may be further more readily facilitated, a portion of the exterior walls equal to not less than 10 per cent of the combined area of the inclosing walls shall be of glass; provided that when in a building with other processes not more than 40 per cent of the aggregate area of the exterior walls shall be of such material. All glazing shall be by means of thin glass not exceeding a thickness of ¼ in.; wall or walls thus treated shall be so located that in case of an explosion its force will be vented in direction or directions of least exposure.

3. Ventilation and Dust Collection—(a) All buildings in which the processes of crushing or pulverizing are carried on shall be well ventilated to the outer air.

(b) The atmosphere of the room shall be kept as free as possible from suspended or floating dust, by means of approved dust-collecting systems, the collection of dust to take place as near the point of origin as possible.

(c) Static Dust—Good housekeeping is a factor of the utmost importance. To this end every coal drying and pulverizing plant shall be kept free from even small accumulations of coal dust. It is recommended that all interior surfaces be either whitewashed or painted white and cleaned at sufficiently frequent intervals to prevent such accumulations of coal dust.

Interior surfaces should be cleaned in such manner that no dust will be scattered or distributed. To this end it is recommended that dust removal be accomplished by an adequate pneumatic or vacuum sweeping system, or that the dust be thoroughly wetted down before being disturbed. The use of compressed air for blowing dust from motors or other equally inaccessible places is recommended, but the general use of compressed air for blowing dust from walls and other interior surfaces is prohibited.

(d) Because of the hazard attending the operation of motors and the use of flexible electric cable in coal-pulverizing plants, the use of portable vacuum cleaners or air compressors is not recommended. Portable tanks containing compressed air may be used providing no electrical equipment is operated inside of the pulverizing room in connection therewith.

(e) Pneumatic sweeping systems if installed, shall comply with the following general requirements

1. Such systems shall be of sufficient power and capacity to accomplish effective results.

2. Nozzles, handles and other movable parts shall be constructed of non-ferrous metal, fiber or other non-sparking material.

3. Nozzles, handles and flexible hose shall be electrically grounded to the piping system and the piping system effectively grounded to the earth.

4. Dust separation shall take place before the dust reaches the exhauster; the separator or separators shall accomplish practically complete separation as there should be no perceptible discharge of dust from the exhauster. The dust entering the separator shall not directly strike a metallic surface.

5. The exhauster should preferably have no moving internal metallic parts in contact.

6. The motor and separator should preferably be located outside of the pulverizing room.

Note: Specifications for removal of suspended dusts are in course of preparation.

4. Crusher and Pulverizer—All crushing and pulverizing mills shall be provided with approved devices to guard against the hazard of fire or explosion, and be operated under competent supervision. Power for operation of mills shall be controlled remotely at a readily accessible location and at the mill. Crushers, pulverizers, shafting and other metal parts of equipment, and belts shall be electrically grounded in an effective manner.

5. Magnetic Separator—(a) A magnetic separator shall be provided for each system employing pulverizing mills, and installed between the crusher and the drier.

(b) The conveyor shall be of sufficient width, and the magnetic separator of such size as to expose, and insure the removal of tramp iron or other magnetic substances.

6. Electricity for Light and Power—All electrical equipment for light and power in pulverizer house shall conform with the National Electrical Code. Provision shall be made for remote control in order that current for light and power may be cut off in an emergency without entering pulverizer house.

7. Dust Collectors—All dust collectors shall be constructed of non-combustible material and located in a separate room and preferably outside of main buildings, properly vented to safe point outside of building. Cloth type collectors shall be located in tight metal enclosures or their equivalent, be vented to a safe point outside of the building, and electrically grounded in an effective manner.

8. Vents—Pressure relief vents shall be liberally provided on all pulverizing equipments, particularly at the mill in the discharge therefrom; at elevator heads and at every storage bin for pulverized fuel. Storage bin vents shall have a cross-sectional area sufficiently large to permit the separation of air from fuel without building up an abnormal pressure within the bin. All vent pipes shall lead by the most direct route to outside air.

9. Blowers—(a) Blowers shall be installed on proper foundations and secured in a substantial manner. They shall not be used for any other purpose, but this shall not be construed as prohibiting the use of a blower as a means of supplying secondary air also.

(b) Bearings of blowers shall not extend inside of blower casings or ducts.

(c) All connections between discharge end of blower and main duct shall be so made as to prevent leakage of fine dust.

10. Driers—(a) The drier and drier furnace shall be separated from other equipment in the pulverizer house by means of incombustible partitions constructed of material having a fire resistance of not less than one hour based upon the standard specifications for fire tests and materials of construction.

(b) Driers shall be of a type such that the products of combustion of the heating unit shall not come in contact with the fuel being dried, except at a distance of at least one-half the length of the drier, and in no case within 12 feet of the fuel bed.

(c) Pulverized coal exceeding a temperature of 150 deg. F. shall not be stored in any bin. In order to assist in regulating the temperature of the coal, a recording thermometer shall be installed at the discharge end of the drier, the fire-end of which shall be as close to the coal within the drier as practicable.

(d) Every drier shall be designed to prevent gases of combustion from entering its shell when it is not in operation.

11. Dried coal elevator shall be of non-combustible construction, dust-tight as possible, and adequately vented to the outer air.

12. All pulverizing mills and driers shall be constructed as dust-tight as practicable, and so operated as to avoid leakage of dust.

13. Fire Protection—Every building or room containing the foregoing processes shall be provided with approved fire extinguishers in such quantity and of such type as outlined in the National Fire Protection Association Regulations for the Installation, Maintenance and Use of First Aid Fire Appliances. Wherever the introduction of combustible material into the pulverizing room makes automatic sprinklers necessary for fire protection, their arrangement and control shall be approved by the Inspection Department having jurisdiction.

Class A Systems

14. Piping—All fuel-conveying piping shall be of metal, substantially supported and properly safeguarded against mechanical injury.

15. Joints and Valves—All pipe joints shall be securely made so as to insure a dust-tight installation. All control, switching and shut-off valves shall be of dust-tight construction.

16. Every coal conveying line shall be located away from all open flames or open lights of any kind, and at safe distance from sources of radiated heat, such as furnaces, ovens, boiler settings, etc.

17. Storage and Furnace Bins—(a) Storage and furnace bins shall be located as far as consistent with operating requirements from furnaces, and away from open flames or open lights of any kind. Location shall be such that no radiation from furnaces, boilers, steam pipes or flues, or other heating appliances can materially raise the temperature of the contents of the bin. Where practicable, bins used in connection with pair and sheet furnaces, billet furnaces, annealing furnaces, etc., shall be placed outside of main building. Where this is not feasible, they shall be separated from the furnace by a non-combustible partition.

(b) Bins shall be of non-combustible construction and shall be so shaped that no material will be left in the corners under normal emptying operation of the bin. Material used in construction of metal bins shall be steel of sufficient thickness to secure ample mechanical strength. Joints shall be riveted or welded; size and spacing rivets shall be such as to secure a dust-tight joint. Dust-tightness shall also be secured in cases where metal bins are lined with concrete, or where bins are constructed of concrete.

(c) Except for vent openings, all storage and furnace bins shall be normally tightly closed. Those bins which are filled by transporting pulverized coal by means of air, either under pressure or by a fan, shall be properly equipped with cyclone collectors or other equivalent devices for preventing the transport air from entering the bin and raising a dust cloud.

(d) All bins shall be equipped with a reliable gaging device so that the quantity of fuel in the bin may be readily determined without exposing the contents. At no time shall there be any pressure other than that caused by the weight of the fuel in any pulverized-fuel storage bin.

18. Screw Conveyors—Systems using screw conveyors for handling pulverized fuel shall be arranged with driving power applied at the discharge end. Where the length of transfer is too great for a single screw so driven, any additional units shall be similarly driven and so interconnected that the stopping of the last screw in the series will automatically stop the others, or as an alternative for such interlocking, the junction point between the two screw conveyors shall be placed outside of the building.

19. (a) In no plant shall coal-storage bins, conveying machinery or fuel-pipe lines be used as supports for electric lighting or power lines other than those installed in conduit.

(b) Machinery and all other parts comprising the crushing, drying, pulverizing and conveying system shall be electrically grounded in an effective manner.

Class B Systems

20. Piping—(a) Distributing piping shall be of suitable metal pipe; flanged joints may be used. Piping and fittings shall be designed to withstand safely the maximum working pressure that may be exerted and so installed as to be safeguarded adequately against mechanical injury.

(b) In each switch or branch line to burner there shall be installed a suitable check which will be positive in operation

21. Joints and Valves—All pipe joints; control, switching and shut off valves shall be of dust-tight construction.

22. Every coal conveying line shall be located away from all open flames or open lights of any kind, and at safe distance from sources of radiated heat, such as furnaces, ovens, boiler settings, etc.

23. Blowers—(a) Primary blower shall be operated and maintained at a rate producing a primary air pressure higher than that of the secondary or booster.

(b) Motor circuits for primary blower and booster fan shall be protected by the same circuit breaker switch or other protective device, so that the stopping of either will cause the simultaneous stopping of the other.

24. Vents—In the opinion of the committee, except in the case of piping 2-inches and smaller in diameter, the distributing piping should be vented as directly as possible to the outer air, the vents being preferably located at the ends of long trunk mains and at sharp bends in the larger pipes and closed under normal conditions by weighted covers giving suitable light pressure on soft dust-tight non-sticking gaskets, or by other equivalent device. This is common practice in other dust collecting and conveying systems. In this case the committee has deemed such vents necessary owing to the possibility of the propagation of flame and consequent greatly increased pressures throughout the piping system.

On the other hand manufacturers take the stand that the dust in suspension would seep through the weighted covers normally closing the vents and form a slug of coal dust which would prevent operation of the cover and thus defeat the intent of this provision. In view of these claims the committee has not taken a decided stand and is leaving the matter open pending the receipt of opinions of those experienced in the operation of this type of system.

25. Storage Bins—Bins shall be of non-combustible construction and shall be so shaped that no material will be left in the corners under normal emptying operation of the bin. Material used in construction of metal bins shall be steel of sufficient thickness to secure mechanical strength, joints shall be riveted or welded; size and spacing of rivets shall be such as to secure a dust-tight joint. Dust-tightness shall also be secured in cases where metal bins are lined with concrete or where bins are constructed of concrete.

26. (a) In no plant shall coal-storage bins, conveying machinery or fuel-pipe lines be used as a support for electric lighting or power lines other than those installed in conduit.

(b) Machinery and all other parts comprising the crushing, drying, pulverizing and conveying system shall be effectively electrically grounded.

Unit Systems

27. Pulverizer—Pulverizer shall be provided with approved devices to guard against the hazard of fire or explosion, and be operated under competent supervision. Power for operation of pulverizer shall be controlled remotely at a readily accessible location and at the mill. Pulverizer, blower and all other metal parts of the equipment, and belts shall be electrically grounded in an effective manner.

28. Magnetic Separator—(a) A magnetic separator shall be provided for each system. In cases where the coal is crushed before being conveyed to the pulverizer, the magnetic separator shall be installed between the crusher and the pulverizer.

(b) The conveyor shall be of sufficient width and the magnetic separator of such size as to expose, and insure the removal of all tramp iron or other magnetic substances.

29. Electricity as Power for Operating—All motors, switches and other electrical devices in connection with equipment shall conform with the National Electrical Code.

30. Vent—A pressure-relief vent discharging to the outside air shall be provided in the discharge of every pulverizer, having discharge pipe greater than 4 in. in diameter and exceeding 20 ft. in length.

31. (a) Blower—Blower shall be installed on proper foundation and secured in a substantial manner.

(b) Bearings of blower shall not extend inside the blower casing or ducts.

(c) All connections between discharge end of blower and main duct shall be so made as to prevent the leakage of fine dust.

32. All pulverizers shall be constructed as dust-tight as practicable and so operated as to avoid emission of dust.

33. If a crusher, drier or other equipment is also used, installation shall be in accordance with the general requirements for Class A and B systems.

INSTRUCTION CARDS

Class A and Class B Systems

34. An instruction card including the following precautions relating to safe operation shall be conspicuously posted in the pulverizing plant, boiler plant and in buildings where pulverized fuel is used

(a) The crushing, drying and pulverizing plant should be under the supervision of a thoroughly competent and reliable foreman and only competent and reliable workmen should be employed in connection with these operations.

(b) The use of shavings or other similar light combustible materials for starting fire in drier furnace is prohibited.

(c) The operation of the drier shall not be stopped while it contains a charge of fuel.

(d) Whenever a plant has been idle for a period of two days or more, all storage bins shall be thoroughly inspected before resuming operation.

(e) Damper in drier chimney uptake shall be wide open when fire is started.

(f) In Class B Systems, if fuel supply line becomes clogged, the furnace shall be immediately cut off and the secondary air stopped. When obstruction has been cleared and before starting fan, a thorough examination shall be made to insure the removal of smoldering particles of fuel.

(g) All fuel supply lines (of Class B and Unit System types) shall be blown clear of fuel when shutting down at close of day.

(h) All conveyors and elevators shall be tightly and securely inclosed and never opened while running. Previous to opening, machinery shall be stopped and dust allowed to settle for a period of 20 minutes.

(i) All stationary lights shall be protected with vapor-proof globes and wire guards. Only daylight or hand flash lights shall be used when inspecting coal-storage bins and pulverizing and coal conveying apparatus. All conveying and distributing piping shall be inspected daily and any leaks promptly repaired.

(j) Smoking and the use of open lights or torches shall be prohibited in the crushing, drying and pulverizing plant.

Note: In the case of Unit Systems Instruction Card shall include paragraphs 34, 34(a), 34(e) and 34(g).

Large Transformer Order for French Railway

The Westinghouse Electric & Manufacturing Co. has built for the Chemins de Fer de Midi, France, twenty-five transformers rated 6,667-kva. each. These transformers are going to be used on a nominal 150,000 volt 50-cycle system, which is to be the voltage adopted for the new national transmission system. It is the highest voltage thus far used in Europe. The transformers are of the shell type and are arranged to be cooled by forcing the oil through external coolers. Eleven are step-up units designed for connection in 20,000-kva. three-phase banks to raise the voltage from 60,000 volts delta to 154,000 volts star.

The remaining fourteen transformers are designed to step down from 154,000 volts star to 60,000 volts delta. They are larger than the step-up units, for they include 5,333-kva. tertiary windings which will be used to provide 16,000-kva. three-phase at 6,600 volts for the operation of synchronous phase modifiers. Each transformer will have its own pump and its own oil cooler of the tubular type, in which the oil circulates around the tubes and the cooling water flows through the tubes in the opposite direction. The oil circulates at the rate of 110 gal. per min. and the water at the rate of 53 gal. per minute.

In abstracting the report on "Progress in Power Development" by Prof. A. G. Christie as retiring chairman of the Power Division of the A.S.M.E., printed in the Feb. 6 issue, credit to *Mechanical Engineering* was inadvertently omitted.

News in the Field of Power

Compare the Use of Power in 1914 and 1919

Figures recently published by the Census Bureau on the number and horsepower of prime movers in New York State and Illinois show an increase between 1914 and 1919 of roughly 25 per cent in each state. This increase was due chiefly to the gain in "rented" power (power purchased from public utilities). In Illinois the purchased power amounted, in 1914, to 284,171 hp. and in 1919 to 596,212 hp., representing an increase of 109.8 per cent. In New York State the corresponding figures were 679,652 and 1,180,544 hp., an increase of 73.7 per cent.

It is interesting to note that privately generated power increased only about 5 per cent in each state during the five-year period. Another interesting point is that in 1919 the amount of privately owned power in Illinois was approximately equal to that generated by public utilities, whereas in New York State the public utilities produced more than twice as much power as that generated in private plants.

Japan Our Best Customer For Power Apparatus

Japan spent more money on American-made steam turbines and electric generators in December than any other country, according to figures just released by the Department of Commerce. In that month, Japan bought from this country two steam turbine units whose combined cost was $57,920, while the Provinces of Quebec and Ontario, Canada, came next on the list, with six turbines having a total value of $21,284.

In the electrical-apparatus field Japan bought six direct-current generators of less than 500 kw. rating for $11,809; Quebec and Ontario paid $6,310 for 87 such units, and Argentina bought 31 units, having a total value of only $865. For d.c. generators of 500 kw. and over, Japan again heads the list with five units valued at $35,099, while the Prairie Provinces of Canada came next with one unit costing $11,560. Japan bought also four alternating-current generators of less than 2,000 kw. rating, valued at $15,033. The nearest approach to this figure was Mexico's purchase of one such unit, valued at $3,994.

Seasonal Storage Favored As a Means of Stabilizing the Coal Industry

John W. Lieb Suggests Needed Changes in the Coal Industry to Insure an Adequate Supply

AT THE February luncheon meeting of the New York Electrical League, held at the Hotel Astor, John W. Lieb, vice-president of the New York Edison, in an address, "The Electrical Industries and the Coal Situation," set forth the way in which the electrical industries have been affected by conditions in the coal industry, how they are serving the nation in the conservation of fuel and simplifying its distribution, and some of the related problems affecting the mining and distribution of coal. Of the various plans proposed for stabilizing the coal business, Mr. Lieb favored the one whereby through the extension of the storage of coal by all users, the seasonal variation of prices of coal and possibly seasonal variation of freight rates, by conservation or economy in the use of coal, and by simplifying its distribution, conditions can be materially improved. With regard to this plan Mr. Lieb said in part:

Of the methods for ameliorating fluctuating conditions in the coal industry, the proper use of storage seems to offer exceptional advantage. The utilities for self-protection early inaugurated the policy of maintaining generous storage of coal at their plants. Indeed, they have been leaders in this regard, and through wise buying and handling of these storages have proved to be a helpful stabilizer to the coal industry. The large amount of coal they have put in storage prior to the beginning of the great coal strike on April 1, 1922, was a material element in saving the country from a catastrophe of large dimensions.

Larger storage capacities for all coal users, to be filled at times during the year when transportation facilities are best available, would do much to remedy the present unsatisfactory fuel conditions. The railroads themselves should, in as great measure as possible, haul and store the coal for their own needs during periods when their facilities are not pressed by peak loads. They use approximately a third of the bituminous coal consumed, and thus they are in an excellent position to aid to a much greater extent than in the past in stabilizing both the coal industry and their own operations through such methods.

Further, the mines can in a certain measure promote storage which would prevent the irregular daily production outputs from the mines, caused by variations in daily car supply. In many locations a coal pocket holding from one to two days' output, may be installed at a moderate expense and so arranged as to discharge directly into the railroad cars with little additional equipment and no additional handling. Such a storage should enable the mine to run continually at least five days a week and the slight additional cost would be largely overbalanced by improved showing in the overhead per ton of coal produced. The overhead expenses go on while the mine is idle. These expenses amount to about 40 per cent of the total cost of the coal on the car. Those mines which have installed storage of this kind find that under most conditions the car supply is equalized and that definite advantages result from the practice.

It is evident that this remedy is not of universal application, since thickness of seam, number of working places, length of haulage and quality of coal, as well as the physical configuration of the surface works, affect the problem.

It has frequently been suggested that such expense and transportation difficulty could be saved to the electric utilities and steadiness of mine output could be promoted by the location of generating stations at the mine mouth with the transmission of the power so generated to the point of use. This has been done in a number of cases in England, on the Continent, and to some extent in America, and it has been found that wherever adequate water supplies existed for condensing purposes, the installation has been successful. This condition, however, does not obtain in the majority of cases. Speaking broadly, it must be remembered that for every ton of coal burned in the power station, from 600 to 1,000 tons of water must be provided for condensing purposes.

It is unfortunate that very few rivers of adequate size to provide this flow are available in the coal regions, and it is apparent that the object to be secured by placing the station in the coal region has in most cases been impossible of attainment.

The project of pumping coal through a pipe line has been considered by many engineers and its feasibility has been shown, at least theoretically. The cost and design of the apparatus is well known, and no engineering difficulties are entailed in its operation.

An advantage of all stabilization methods is that it will tend to furnish more continuous employment to miners and thus improve the economic and social conditions of the mine workers. It has been asserted that much of the labor discontent and difficulty at the mines has come through irregular employment and an excessive amount of enforced idleness. Though much of this has resulted through the seasonal character of the business, which can be in large measure corrected, yet it is asserted on the contrary that the miners themselves have frequently been the cause of idleness through refusal to work steadily through the week.

To Finance Standardization by New Method

A new plan for financing the industrial standardization work of the United States has been formally approved by the executive committee of the American Engineering Standards Committee.

This committee, organized in 1918, has heretofore been financed entirely by dues from the nine technical societies and seventeen national trade associations which, with seven departments of the federal government, constitute its present membership. Annual deficits were cleared by contributions from individual corporations.

It is expected that the new plan of financing will provide an annual budget of $50,000 for the Standards Committee. As this sum is to be realized from sustaining membership dues amounting to $\frac{1}{1000}$ of one per cent of gross receipts, the total of $50,000 would be spread over industries with aggregate gross annual receipts of five billion dollars. The plan calls for the appointment of an engineer-translator to provide translations of standards developed in foreign countries for the information service to sustaining-members.

Among the noted engineers and financiers making up the advisory committee on the new financing plan are John W. Lieb, E. W. Rice, Jr., E. M. Herr, Dr. S. W. Stratton and John R. Freeman.

Would Have Cities of N. Y. Own Utilities

A measure giving all cities in New York State except New York City the right to own and operate all public utilities within their boundaries, was introduced in the lower house of the legislature on Feb. 19. According to this bill, purchases of utilities would be made with cash raised by taxes or bond issues.

The measure possesses a redeeming feature, as far as the public-utility corporations are concerned: It is not mandatory in its provisions, that is, the cities are not obliged to take over their public utilities if they do not want to. If passed, however, this measure will not only keep the fear of the political machine over the heads of the public-utility corporations, but in case a state plan of water-power development goes into effect, will enable the communities to go into the business of selling power to the consumer, once it is delivered by the state to the city boundaries.

The new 10,000-hp. water-power plant of the Pacific Power & Light Co. on the Hood River, near the town of that name in Oregon, will be placed in operation by March, according to present indications. This plant, costing $1,250,000, will be tied in with the Condit hydro-electric plant of the Northwestern Electric Co., on the opposite side of the Columbia River.

Water-Power Projects

The Federal Power Commission has authorized an amendment to the license issued the Utah Power & Light Co. for its Soda Point project on the Bear River in Idaho, which will permit it to relocate its dam and powerhouse. This action was taken because geologists fear there would be excessive leakage in the bedrock under the proposed dam. The new site is 1,200 ft. upstream, where foundation uncertainty is avoided.

Favorable action was taken on the application of the Mokelumne River Power and Water Co., of San Francisco, for a preliminary permit, covering a combined power and irrigation project on the South and Middle Forks of the Mokelumne River and the North Fork of the Calaveras River.

An extension of one year in the time limit of the preliminary permit of the Lower Niagara River Power and Water Supply Co., of New York, has been granted. The company was issued a preliminary permit on March 3, 1921, for a period of two years.

The preliminary permit issued to R. G. McDonald, of Williams, Calif., on June 15, 1922, covering a project on Convict Creek, has been revoked on the ground that he has failed to carry out the engineering investigations and the stream gaging required by the terms of the permit.

Representatives of the states of Washington, Idaho and Montana and of the Montana Power Co. have been invited by the executive secretary of the Commission to appear before him on March 15 in connection with the Flathead Lake development proposed by the Rocky Mountain Power Co. The principal question is whether the power company should make full development of the storage or whether the Washington authorities should be allowed to develop a part of the storage.

The development of hydro-electric power in the vicinity of Louisville has been further complicated by the entry upon the scene of Indianapolis interests, who have filed a declaration of intention covering power development on the Cumberland River.

Formal protests have been filed with the Commission by the municipalities of Bristol and Bluff City and by the County of Sullivan against the application of the Holston River Power Co., covering three sites on the Holston River. The protest discloses that public development of that stream is in contemplation. As a result of this protest, the district engineer at Chattanooga has been instructed to conduct a local hearing.

The Tennessee Hydro-Electric Co., Knoxville, has applied for a preliminary permit for projects on the Clinch and Powell Rivers in Tennessee and Virginia, tributaries of the Tennessee River. An ultimate installation of 390,000 hp. is contemplated. New York and Pittsburgh interests financing this company are also the applicants for a preliminary permit covering three projects on the Holston River.

The Virginia Power Co., a going concern in West Virginia, has applied for a preliminary permit for a large development on New River, five miles above Hinton.

Nine applications for permit or license were filed with the Commission during the three weeks' period ended Feb. 10, making a total of 387 applications received to that date.

New Publications

Economic Combustion of Waste Fuels. By David Moffat Myers. Technical Paper 279 of the Bureau of Mines, Department of the Interior, Washington, D. C. Price, 10c.

This bulletin gives furnace designs, methods of firing and test data for the burning of a large variety of waste or byproducts fuels.

Glossary of Electrical Terms and Instructions to Exporters. Revised edition, published by the Department of Commerce, Washington, D. C. Price, 5c.

This glossary is intended for reference by exporters in making out their declarations. In it are listed alphabetically all articles classed as electrical products, with the export classification number of each article, according to the schedule revised on Jan. 1, 1923. In addition, the glossary contains instructions to exporters of articles so large that they must be shipped in more than one consignment. It may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Sampling and Analysis of Coal, Coke and Byproducts. Second Edition. By Chemists' Committee, United States Steel Corporation. Published by The Carnegie Steel Co. Bureau of Instruction, Pittsburgh, Pa., 1923. Limp Leather; 5x7¼ in.; 184 pages; 18 illustrations and numerous tables. Price, $3 postpaid.

This book gives most of its space to a consideration of the following subjects: Sampling; physical tests; analysis of coal, coke and ash; calorific value; analysis of byproducts; testing of benzol products. The material relating to coal and ash should be of great value to power-plant engineers because it represents the practice of a company that has had broad experience along this line. Many changes have been made from the first edition, and much new material has been added. Among the new features are sections on the physical testing of coke, determination of the different forms of sulphur in coal, determination of the fusibility of coal ash and coke ash and a number of new tables. The book is a handy pocket size and is neatly put together with limp leather cover, rounded corners and gilt edges.

Obituary

David Augustus Decrow, prominent engineer and manager of the waterworks department of the Worthington Pump & Machinery Corp., passed away on Feb. 15. Mr. Decrow was born in Bangor, Me., and graduated in 1879 from the University of Maine. He went from Maine to Lockport in the early eighties and became associated with the Holly Manufacturing Co. as a mechanical draftsman. In 1900 he was made chief engineer and in 1903 secretary of this company. When the Holly company became a part of the International Steam Pump Co., Mr. Decrow took charge of the manufacture of pumping machinery by both companies. In 1916, when the International company was taken over by Worthington, Mr. Decrow was promoted to the position that he held at the time of his death. He was an active member of the A.S.M.E. and was chairman of the Committee for the Revision of the Test Code for Reciprocating Displacement Pumps.

Harvey S. McLeod, one of the most widely known men in the field of refractories, died Feb. 16. Engineers in the power-plant field will learn with regret of his decease.

Mr. McLeod, who was born in 1843, was a veteran of the Civil War. Shortly after his discharge from the Union forces he engaged in the retail stove and cornice business in Troy, N. Y. In 1882 he bought the interests of Bacon & Henry, firebrick manufacturers, and in 1887 incorporated it under the name of McLeod & Henry Co. The success which this company achieved was due largely to Mr. McLeod's active administration.

Mr. McLeod's business was but a part of his career. During his entire life he devoted both his time and income to helping others. He not only lent his financial support to charitable institutions but gave liberally to individuals struggling for an education. His memory will be cherished by all those who came within his kindly influence.

Society Affairs

New York Section, A.S.R.E. will hold their regular meeting on the evening of March 7 at the Machinery Club, 50 Church St. Dinner will be served at 6:30 p.m. in the dining-room of the club. Jim Scott will speak on "The Outlook for the Ice Industries."

Providence Engineering Society and **Rhode Island Section, American Chemical Society,** will consider "The Development of New Motor Fuels to Replace Petroleum," at a joint meeting on Mar. 6 at the society rooms, 44 Washington St. Ralph H. McKee, professor of chemical engineering at Columbia University, will speak.

Cleveland Engineering Society will hear Gardner S. Williams, consulting engineer of Ann Arbor, Mich., on "The Great Lakes-St. Lawrence Waterways Project," at its meeting on Mar. 6 at the Hotel Winton. On Mar. 14 Col. Hugh L. Cooper, consulting engineer for the Frontier Corp., New York City, will speak before the society on "The Proposed Hydro-electric Development on the St. Lawrence River."

Affiliated Technical Societies of Boston will hold their first affiliation dinner on March 7 at the Copley-Plaza Hotel at 6:30 p.m. The speakers will include Dr. S. W. Stratton, president of Massachusetts Institute of Technology, and John Hays Hammond, well-known consulting engineer and chairman of the United States Coal Commission. The affair will be informal.

Coming Meetings

American Chemical Society, Gas and Fuel Section; R. S. McBride, Colorado Bldg., Washington, D. C. Motor fuel symposium at New Haven, Conn., April 6.

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Pacific coast regional meeting at Los Angeles, Apr. 16-18; spring meeting at Montreal, Canada, May 28-31.

Society of Industrial Engineers; George C. Dent, 327 S. La Salle St., Chicago, Ill. Spring convention at Cincinnati, Ohio, Apr. 18-20.

American Welding Society, 29 W. 39th St., New York City. Annual meeting at New York City, April 27-28.

American Association of Engineers, 63 East Adams St., Chicago, Ill. Annual convention at Norfolk, Va., May 7-9.

American Water Works Association, 153 W. 71st St., New York City. Annual meeting at Detroit, Mich., May 21-25.

National Electric Light Association; M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

Electric Power Club; S. N. Clarkson, Kirby Bldg., Cleveland, Ohio. Annual meeting at Hot Springs, Va., June 11-14.

American Institute of Electrical Engineers, 29 W. 39th St., New York City. Annual convention at Swampscott, Mass., June 25-29.

American Society for Testing Materials; C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 25-30.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows:

Kansas, at Fort Scott, Apr. 4-6; C. H. Taylor, 517½ W. 6th St., Topeka.

Business Notes

Mitsui & Co. has been appointed representative in Japan and China for the Uehling Instrument Co., Paterson, N. J.

The Webster Manufacturing Co., Chicago, Ill., has formed a new company—Webster-Inglis, Ltd., 14 Strachan Ave., Toronto, Canada—in connection with its Canadian business. This company will manufacture elevating, conveying and power-transmission machinery, along the lines now made by the Webster company.

Trade Catalogs

Boilermakers' Tools — J. Faessler Manufacturing Co., Moberly, Mo. Catalog No. 36 describing, illustrating and giving prices of Faessler tools for the boilermaker.

Ventilating Fans—Clarage Fan Co., Kalamazoo, Mich. A bulletin containing photographs of schools and other public buildings ventilated with "Clarage-Kalamazoo Multiblade" fans, with names of the architects and heating and ventilating contractors. Emphasis is laid on the need for good ventilation in public buildings, and the services of the company in this connection are briefly but adequately described.

Grinding Mills, Conical — Hardinge Co., 120 Broadway, New York City. Catalog No. 13, Section 1, describing the Hardinge method of pulverizing and grinding, both wet and dry. The Hardinge Conical Mill revolves on a horizontal axis and uses cast-iron or forged-steel balls or imported flint pebbles as the grinding agents. Tables of dimensions of the different types are given.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Feb. 19 1923	Feb. 26 1923
Pool 1,	New York	$4.50–5.15	$4.50–5.00
Smokeless,	Columbus	4.25–4.50	4.25–4.75
Clearfield,	Boston	3.50–4.25	3.50–4.00
Somerset,	Boston	3.75–4.50	3.75–4.25
Kanawha,	Columbus	2.50–2.75	2.75–3.00
Hocking,	Columbus	2.40–2.65	2.50–2.75
Pittsburgh No. 8	Cleveland	3.15–3.25	3.75–4.00
Franklin, Ill.,	Chicago	3.25–3.50	3.25–3.50
Central, Ill.,	Chicago	2.50–3.75	2.50–2.75
Ind 4th Vein,	Chicago	3.00–3.25	3.00–3.25
West Ky.,	Louisville	1.85–2.25	2.00–2.40
S. E. Ky.,	Louisville	2.25–3.00	2.75–3.00
Big Seam,	Birmingham	2.00–2.25	2.00–2.25

FUEL OIL

(f.o.b. city unless otherwise specified)

New York—Feb. 21, Port Arthur light oil, 22@25 deg. Baumé, 4¼c. per gal.; 30@35 deg., 5¼c. per gal., f.o.b. Bayonne, N. J.

Chicago — Feb. 24, 24@26 deg. Baumé, $2.02 per bbl.; 32@36 deg., $2.39 per bbl. in tank cars.

Philadelphia—Feb. 26, 26@28 deg. Baumé, Oklahoma, $1.02½@$1.05½ per bbl.; 32@36 deg., Oklahoma (group 3), 3¼@3¾c. per gal.; 16@20 deg. Seaboard, $1.05@$1.15 per bbl.

St. Louis—Feb. 23, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.95 per bbl.; 26@28 deg., $2.10 per bbl.; 28@30 deg., $2.20 per bbl.; 30@36 deg., gas oil, 5¼c. per gal.; 36@40 deg., distillate, 5¾c. per gal.

Pittsburgh—Feb. 24, t.o.b. local refinery, 30@34 deg., fuel oil, 6¼c. per gal.; 36@40 deg., fuel oil, 6½c. per gal.; 34 deg., neutral, 8¼c. per gal.

Dallas—Feb. 24, f.o.b. local refinery, 26@30 deg., $1.43 per bbl.

New Plant Construction

PROPOSED WORK

Calif., Fresno — The Stinson Irrigation Dist. will hold an election Mar. 9 to vote on a $360,000 bond issue for the construction of additional canals, wells, reservoirs and installation of pumping plants. Quinton, Code & Hill, Hollingworth Bldg., Los Angeles, Engrs.

Calif., Los Angeles—W. M. Garland, 749 South Spring St., is having plans prepared for the construction of a 12 story office building on Spring and 9th Sts. Estimated cost $850,000. Curlett & Beelman, Union Bank Bldg., Los Angeles, Archts. Equipment detail not reported.

Calif., San Diego—The San Diego Hotel Co. is having plans prepared for the construction of a 7 story addition to its hotel on State St. Estimated cost $500,000. W. H. Wheeler, I. W. Hellman Bldg., Los Angeles, Archt. Equipment detail not reported.

Calif., San Francisco — Bliss & Faville, Archts., Balboa Bldg., are preparing plans for the construction of a 9 story hotel and club building on Sutter and Mason Sts. Estimated cost $750,000. Owner's name withheld. Equipment detail not reported.

Calif., San Francisco—The Kiel Estate plans to build a 3 story department store on Mission St. near 22nd St. Cost will exceed $500,000. Engineer or architect not selected. W. R. Davis & Bro., 2528 Mission St., lessee.

Calif., San Francisco—The Mount Moriah Hospital Assn., c/o C. Werner, Archt., Santa Fe Bldg., is having plans prepared for the construction of a 6 story hospital, first unit to contain 75 rooms. Estimated cost $225,000, ultimate cost $1,000,000. Equipment detail not reported.

Calif., San Rafael—The Pacific Gas & Electric Co., 445 Sutter St., authorized the construction of new generator and accessories, also 125 hp. compressor. Estimated cost $43,091 and $15,295 respectively.

Calif., Taft—The Central California Ice Co., P and Mono Sts., Fresno, has purchased site and plans to build an ice plant on 6th St., here. Estimated cost $50,000.

Conn., Greenwich — The High School Bldg. Comn. is having plans prepared for the construction of a 3 story high school with auditorium, including steam heating plant, lighting, power and modern ventilating systems, on West Elm St. Estimated cost $800,000. Guilbert & Betelle, 546 Broad St., Newark, N. J., Engrs. and Archts.

Fla., Pensacola—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., plans the construction of a pump house, timber trestle, piping and equipment. Estimated cost $18,000.

Fla., Tampa—Kingman & Co. is in the market for ice manufacturing machinery and equipment for $90,000 plant under construction.

Ill., Chicago—W. W. Ahlschlager, Archt., 65 East Huron St., will soon receive bids for the construction of an 18 story, 156 x 160 ft. apartment building, including steam heating system, on Sheridan St. near Grace St., for A. Willie, c/o Archt. Estimated cost $2,100,000.

Ill., Chicago—The Butler Bldg. Corp., c/o C. A. Eckstrom, Archt., 5 North La Salle St., is having plans prepared for the construction of a 16 story, 77 x 80 ft. store, office and shop building, including steam heating system at 168-172 North State St. Estimated cost $1,000,000.

Ill., Chicago—The Ford Motor Co., Woodward Ave., Highland Park, Mich., will receive bids until March 10, for the construction of a 94 x 100 ft. power plant for auto factory with 4 turbines, 3 boilers, stack 165 ft. high above boilers. Equipment includes rubbish burner, 4 condensers, 2 heaters, 2,000 gals. domestic water heater, boiler feed pumps, Duplex sump pump, two 5,000 c.f.m. stoker fans, coal crusher, capacity 50 tons per hour, apron conveyor, capacity 50 tons per hour, and coal and ash handling bunker. A. Kahn, 1000 Marquette Bldg., Detroit, Mich., Engr. Noted Dec. 12, 1922.

Ill., Chicago—O. E. Gallup, c/o W. L. Wallen & Sons, 6712 North Clark St., is having plans prepared for the construction of a 4 story, 180 x 173 ft. apartment building, including steam heating system, on Esler St. near Glenwood Ave. Estimated cost $800,000. McNally & Quinn Co., 10 South La Salle St., Archts.

Ill., Chicago—The Graemere Hotel Bldg. Corp., c/o W. W. Ahlschlager, Archt., 65 East Huron St., is having plans prepared for the construction of an 8 story apartment hotel, including steam heating system, on Washington and Honian Sts. Estimated cost $2,000,000.

Ill., Chicago—A. L. Himelblau, Archt., 179 West Washington St., is preparing plans for the construction of three 5 story, 180 x 358 ft. apartment buildings, including steam heating system, on Washington St. near Le Claire St. Estimated cost $800,000. Owner's name withheld.

Ill., Chicago—The Lake Shore Athletic Club, 28 East Jackson Blvd., is having plans prepared for the construction of a 16 story, 125 x 180 ft. clubhouse, on Chestnut St. and Outer Lake Shore Drive. Estimated cost $2,000,000. J. Hunt, 30 North Michigan Ave., Archt. Steam heating system will be installed.

Ill., Chicago—The Loyal Order of Moose, c/o W. L. Provol, Dist. Supervisor, 67 West Madison St., plans to build a 16 story clubhouse, including steam heating system. Estimated cost $2,500,000.

Ill., Kankakee—B. K. Gibson Co., Archts., 624 South Dearborn St., Chicago, is preparing plans for the construction of a 7 story, 60 x 145 ft. hotel, including steam heating system, here. Estimated cost $3,000,000. Owner's name withheld.

Kan., Larned—The Ideal Laundry Co. is in the market for a 150 hp. tubular boiler.

La., Baton Rouge—The city plans a complete sewerage and water works system, light and power station and other improvements, etc. Estimated cost $1,000,000. J. W. Billingsley, Interstate Bank Bldg., New Orleans, Consult. Engr. P. Converse, Interstate Bank Bldg., New Orleans, Associate Consult. Engr.

La., Elton—The Mayor and Bd. of Aldermen will receive bids until Mar. 14 for machinery and equipment for constructing complete waterworks system and raw water ice making plant. E. Mentz, Magnolia, Miss., Consult. Engr.

Md., Baltimore—Johns Hopkins University, Homewood, is having plans prepared for the construction of extension to tunnel system, consisting of tunnel sewers, water and gas mains, electric feeders, high and low pressure steam and general distribution. C. L. Reeder, 916 North Charles St., Engr.

Mass., Boston—The Moss General Hospital, c/o A. Washburn, M. D., Fruit St., plans to build a 10 story hospital. Estimated cost $300,000. Engineer or architect not selected.

Mass., Brighton (Boston P. O.) — The Florence Crittendon League, 505 Tremont Temple, H. Bancroft, Chn. Com., is having plans prepared for the construction of a 4 story hospital and nurses' home on Oak Sq. Estimated cost $250,000. H. F. Kellogg, 110 Summer St., Archt. Equipment detail not reported.

Mass., Springfield—The Eastern States Refrigerating Co., 343 Bridge St., is in the market for refrigerating machinery and equipment to improve and enlarge present system.

Mich., Detroit—The Cadillac Hotel Co., 234 Michigan Ave., is having plans prepared for the construction of an 18 story hotel to contain 800 rooms, including steam heating equipment. Estimated cost $2,500,000. Engineer or architect not announced.

Mich., Detroit—The Detroit Harmonie Society, Grand River Ave. and Center St., plans to build an 18 story, 60 x 100 ft. hotel and club rooms, including steam heating equipment. Competitive plans will be asked.

Mich., Grand Rapids—B. K. Gibson Co., Archts., 1624 South Dearborn St., Chicago, will soon receive bids for the construction of a 10 story medical science building on Sheldon St., here, for H. A. Brink, 117 Monroe Ave. Estimated cost $1,000,000. Equipment detail not reported.

Mich., Muskegon—The city, E. D. Prescott, City Clk., will receive bids until Mar. 12 for (1) furnishing and laying cast iron watermains with valves and hydrants; (2) steel water tower and tank, capacity 70,000 gal.; (3) pumping station building, receiving well and infiltration gallery on south shore of Bear Lake; also two motor driven centrifugal pumping units, 350 g.p.m. against a total head of 165 ft. and 500 g.p.m. against a head of 165 ft. Hoad, Decker, Shoecraft & Drury, Ann Arbor, Engrs.

Minn., Brainerd—The city, E. T. Flewer, Clk., will soon receive bids for a 200 hp. engine and generator for waterworks pumping station. L. P. Wolff, 1000 Guardian Life Bldg., St. Paul, Engr.

Mo., Annapolis—C. T. Dana et al., International Life Bldg., St. Louis, is having preliminary plans prepared for the construction of a power dam and storage reservoir on Black River, about 800 ft. long and 100 ft. high, from 2,000 to 5,000 hp., to furnish power for Annapolis Lead Co. mines, etc., near Annapolis. Noted July 25, 1922.

Mo., Boonville—J. W. Bozart, Box 274, is in the market for ice plant equipment including engine, belting boilers, refrigeration plant, pulleys and hangers.

Mo., Kansas City—The Gate City Lodge, A. F. & A., No. 522, J. A. Kellan, Secy. Bldg. Com., 507 Mutual Bldg., is having plans prepared for the construction of a 7 story hotel to contain 140 rooms, on 31st St. and Troost Ave. Estimated cost $275,000. Lodge & Gornall, 1505 Commerce Bldg., Archts. Equipment detail not reported.

Mo., Kirkwood—The city voted $105,000 bonds for the construction of a new water works system. The plan is to pump water from deep wells on Meramac River to Kirkwood. C. E. Smith, Railway Exch. Bldg., St. Louis, Consult. Engr.

Mo., Leeper—The land owners of the district, c/o W. H. Meredith, Poplar Bluff, are having preliminary surveys made for the construction of a dam and flood water reservoir on Black River, here, later, plan to develop power from stored floods. Estimated cost $2,000,000. Engineer not announced.

Mo., Marceline — The Walker Gainter Motor Co. is in the market for an air outfit consisting of air compressor, tank and electric motor.

Mo., St. Louis—The Western Union Telegraph Co., 195 Bway., New York, N. Y., has purchased site and plans to build an 8 story, 112 x 135 ft. office building on Chestnut St., here. Estimated cost $750,000. Engineer or architect not announced.

Neb., Lincoln—The Fleisher Constr. Co., 606 Builders Exch. Bldg., Minneapolis, Minn., representing owner, plans to build an 8 story hotel to contain 280 rooms, here. Estimated cost $1,000,000. Private plans. Equipment detail not reported.

Neb., Omaha—Armour & Co., U. S. Yards, Chicago, Ill., plans the construction of a 9 story, packing plant on 30 and Q Sts., to replace one recently destroyed by fire. Estimated cost $2,000,000. R. C. Clark, c/o Owner, Archt. Equipment detail not reported.

N. J., Atlantic City — The Wm. Penn Apartment Co., c/o P. H. Johnson, 1713 Sansom St., Phila., Archt., will soon award the contract for the construction of a 10 story, 53 x 150 ft. apartment building, including steam heating plant on Indian and Pacific Aves. Estimated cost $750,000.

N. J., Glen Rock (Ridgewood P. O.)— The Borough of Glen Rock will receive bids March 26, for the construction of a sewerage system, sewage disposal works and pumping station. Estimated cost $310,000. H. J. Harder, 129 Market St., Paterson, N. J. Engr.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York, is having plans prepared for the construction of a school building (Public School No. 206) on Elmore Pl., here. Estimated cost $1,000,000. W. H. Gompert, Flatbush Ave. Extension and Concord St., Brooklyn, Archt. Equipment detail not reported.

N. Y., Endicott—E. B. Jenny, 32 Vermont Ave., will have plans prepared for development of the "Jenny Tract" including business buildings and shops. Estimated cost $2,000,000.

N. Y., New York — B. F. Keith, 1564 Bway., plan to build a theatre building. Estimated cost $1,000,000. Private plans.

N. Y., New York—The Maxal Realty Co., c/o Schwartz & Gross, Engrs. and Archts., 347 5th Ave., is having plans prepared for the construction of a 20 story, 75 x 100 ft. loft building at 330 7th Ave. Estimated cost $1,500,000. Equipment detail not reported.

N. Y., Remsen—B. K. Brown & Son Co., Inc., F. R. Brown, Purch. Agt., is in the market for ammonia system cold storage machinery and equipment.

N. Y., Watertown—The city voted $415,000 bonds to develop municipal water power at Delano Island. P. B. Sutton, City Engr. Noted Feb. 20.

N. C., Roxboro — The Mayor and Bd. Comrs. will receive bids until Mar. 21 for developing a source of water supply, including laying 20,000 ft. of 12 in. cast iron water pipe; building filter plant, pumping station, reservoir and earth dam with spillway; filter equipment; one 500 g.p.m. centrifugal pump with electric motor, and one 500 g.p.m. centrifugal pump with gas engine drive; clearing impounding 60 acre reservoir site. Ludlow Engrs., Winston-Salem, Engrs.

N. D., Fargo—The Union Light, Heat & Power Co. plans the enlargement of its plant, consisting of 4,000 hp. addition, including 1 turbine generating unit with condenser and auxiliaries, 1 water tube boiler and 1 automatic stoker.

Ohio, Cleveland—The city will receive bids until March 16, for the construction of a 190 x 193 ft. pumping station for waterworks. Estimated cost $500,000. A. V. Ruggles, City Hall, Engr.

Ohio, Columbus—The Bd. Purchase, W. H. Duffy, Pres., City Hall, will receive bids until March 14, for one 400 g.p.m. duplex steam pump, two 500 g.p.m. vertical centrifugal pumps, electrically driven and two 200 hp. boilers, Heine or equal, to be installed at the waterworks plant at the Girls Industrial Home near Delaware.

Ohio, Gambier—Kenyon College is having plans prepared for the construction of a group of college buildings, including dining hall, science building, central heating plant and renovation of Ascension Hall and Kenyon Inn. Estimated cost $200,000, $150,000, $75,000 and $100,000 respectively. A. Garfield, Natl. City Bldg., Cleveland, Archt.

Ohio, Wyoming—The Bd. Trustees, Public Affairs, Office of Water Works, Vine St., will receive bids until March 26, for furnishing one new boiler.

Okla., Oklahoma City — The Baptist Church, 1201 North Robinson St., has had plans prepared for the construction of a 5 story, 140 x 168 ft. hospital at 511 West 12th St. Estimated cost $350,000. R. F. Herbert, 305½ North Robinson St., and C. W. Welborn, 100 West Choctaw St., Archts. Equipment detail not reported.

Okla., Pondcreek—The Booster Club is in the market for complete ice plant equipment.

Ore., Portland — The Oregon Charcoal Iron Co., Corbett Blvd., A. W. Martin, Mgr., is in the market for 1 d.c. electric drive pump to pump 25 sec. ft. water against a 125 ft. head.

Pa., Bernville—The Bernville Light & Heat Co., O. C. Showers, Pres., plans to build extensions and additions to plant and power lines. Cost will exceed $50,000.

Pa., Coudersport—The Abbotts-Aldernay Dairies Co., Inc., is in the market for dairy plant machinery and equipment, including boilers.

Pa., Johnsonburg—The New York-Pennsylvania Paper Co. plans the development of a new water area in Silver Creek Valley, by drilling of at least 100 water wells, 10 in. and 36 in. air compressor lines will be built from the wells to the plant.

Pa., State College—The Pennsylvania State College, c/o H. S. Hoestatter, is having plans prepared and will soon receive bids for the construction of a 3 story educational building. Estimated cost $500,000. Day & Klauder, Franklin Bank Bldg., Archts. Equipment detail not reported.

S. D., Sioux Falls — The Chicago, Milwaukee & St. Paul Ry. Co., 80 East Jackson Blvd., Chicago, is having plans prepared for improvements, including passenger station, freight house, round house, ice plant, water treating plant and terminal yard enlargement, here. Estimated cost $500,000. C. F. Loweth, 80 East Jackson Blvd., Chicago, Ch. Engr.

Tex., Austin—T. B. Baker, San Antonio, representing the Baker Hotel Co. and Sanguinet, Staats & Gottlieb, Archts., 1st Natl. Bank Bldg., Fort Worth, will receive bids until March 15 for the construction of a 15 story, 90 x 110 ft. hotel, here. Estimated cost $500,000. Equipment detail not reported. Noted Dec. 19.

Tex., Fredericksburg — Fredericksburg Citizens Light & Power Co. plans to install a 180 hp. Busch-Diesel engine in the electric plant.

Tex., Kirven — The Gunity & Brazos Valley Railway Co., J. A. Hulen, Receiver, is in the market for 2 portable boilers and engine mounted on 50 hp. cylinder 11 x 12 or 12 x 12.

Tex., Rule—The city, c/o B. L. Jackson, voted a $54,000 bonds for the construction of mains, wells and pumps.

Tex., Wichita Falls — The city council will soon receive bids for the construction of additional pumping unit, direct connected motor and pump, 10,000,000 gal. capacity. Estimated cost $5,000.

Va., City Point—The Wilson-Hock Co., N. Wilson, Mgr., is in the market for a 50 to 75 kw., 3 phase, 60 cycle, 2,300 volt belted generator; 10,000 gal. storage tank made of ¼ in. plate, for gasoline (Hopewell delivery); 20,000 to 30,000 gal. steel tank mounted on approximately 50 ft. steel tower; single phase 60 cycle, 10 kva. transformer, 2,300/110-220 volt; 30 or 40 hp. boiler for 100 lb. steam pressure, complete with all fittings except stack, Scotch marine economic or return tubular boiler, (used); 7 in. steam separator for 150 lb. pressure, equipped with companion flanges; 150 ft. of 400,000 C.M., 600 volt, single conductor lead covered cable; water wheel for driving 60 to 80 hp. of machinery with necessary rigging; steel stacks, self supporting for 2,000 hp. boiler; 16 or 18 motor driven exhaust fans, single phase, 60 cycle, 110 volt motor; 3 phase, 60 cycle, 75 hp., 900 r.p.m., 220 volt slip ring motor with starting equipment; 3, 5 and 10 hp., 3 phase, 60 cycle, squirrel cage motors, 220 volt; 125 to 150 hp. boilers for 135 to 150 lb. pressure, horizontal, return tubular, complete with fittings; two steel towers, each 85 ft. high for power transmission lines.

Va., Richmond—The Hackley Morrison Co., 708 Lewis St., is in the market for a belt driven 125 ft. air compressor.

Va., Roanoke—The School Bd., c/o J. A. Page, will receive bids until March 15, for the construction of a high school, including indirect ventilating and heating system on 6 and Campbell Sts. Estimated cost $600,000. H. C. Richards, 608 Chestnut St., Phila., Archt.

W. Va., Wheeling—The city, C. H. Dowler, City Mgr., will receive bids until Mar. 28 for intake pier; intake line; substructures and superstructures for a 20,000,000 gal. filtration plant and pumping station; heating plant; filter equipment; sluice gates; distributing mains; valves; cast iron pipe; 30 in. steel and cast iron force mains; five 1,000,000 gal. storage tanks; appurtenances. J. N. Chester, Union Bldg., Pittsburgh, Pa., Engrs.

Wis., Milwaukee — G. W. Adams, 114 Grand Ave., is in the market for one 10 ton and one 5 ton ice machine, both motor driven.

Wis., Milwaukee—The Misericordia Hospital, 2224 Chestnut St., plans the construction of a 5 story, 45 x 122 ft. hospital, power house, 50 x 100 ft. laundry building and 40 x 40 ft. kitchen building on Chestnut St. Estimated cost $175,000. Backes & Pfaller, 216 West Water St., Archt.

Wis., Sturgeon Bay — The Dehydrated Products Co., c/o F. Turbush, is in the market for refrigeration machinery, several ton capacity.

Wis., Watertown—The Perfection Table Slide Co., 607 Clyman St., W. C. Schulz, Mgr., is receiving bids for several 75 hp. boilers for heating; 2 dry kilns, 8 car capacity, including equipment.

Ont., Elmira—The Hydro Electric Comn., A. M. Bowman, Supt., is in the market for several transformers. Estimated cost $8,000.

Ont., Hamilton—Culley & Breay, 35 King St. W., are in the market for a large number of small electric motors.

Ont., Kitchener—The Light Comn., V. McIntyre, Mgr., is in the market for one 1,500 kva. transformer.

Ont., London—The London Metal Products Co., c/o C. A. Raftrey, Mgr., is in the market for electric motors.

Ont., Stratford—The Stratford Frames & Novelties, Ltd., is in the market for electric motors for proposed factory.

Wis., Milwaukee—The Western Leather Co., 878 Marshall St., is having plans prepared for the construction of a power plant for its tannery. Equipment includes engine-generator set, two 150 hp. tubular boilers, feed water heater, etc. Cahill & Douglas, 217 West Water St., Engrs.

Ont., Toronto—The McIntyre Monument Co., Queen and Alton Sts., G. McIntyre, Purch Agt., is in the market for an 8 ft. air compressor for a 20 hp. motor, also air tank for same.

CONTRACTS AWARDED

Calif., Los Angeles—The Union Pacific R.R. Co., 610 South Main St., awarded the contract for the construction of power house, garage, car repair and blacksmith shop, boiler shops, traveling cranes and round house in the vicinity of Belvedere Gardens, to the Lynch & Cannon Eng. Co., Chapman Bldg., Los Angeles. Estimated cost $500,000. Noted Dec. 26.

Calif., Los Angeles—The Wilshire-Carondelet Holding Co., c/o Russell & Alpaugh, Archts., Story Bldg., awarded the contract for the construction of an 8 story apartment building on Wilshire Blvd. to the Richardson Bldg. Co., Story Bldg. Estimated cost $700,000. Equipment detail not reported.

Ill., Chicago — The Courts Bldg. Corp., D. H. and H. Burnham, principal owners, 209 South La Salle St., awarded the contract for the construction of a 20 story office building on La Salle and Randolph Sts. to Starret Bros., 8 South Dearborn St., Chicago. Estimated cost $8,000,000. Equipment detail not reported. Noted Feb. 13.

Ill., Chicago — Plotke & Grosby, 2532 North Clark St., awarded the contract for the construction of four 3 story apartment houses, 100 x 100 ft. on Kenmore and Winona Sts.; 100 x 150 ft. on Winthrop St. near Bryn Mawr St.; 100 x 175 ft. on Arlington Pl. near Clark St.; 100 x 190 ft. on Wrightwood St. near Clark St. to the Barrett Constr. Co., 155 North Clark St. Estimated cost $400,000, $400,000, $450,000 and $450,000 respectively. Steam heating systems will be installed.

Ind., South Bend—Robertson Bros., 127 South Michigan St., awarded the contract for the construction of an 8 story, 100 x 150 ft. department store to the H. G. Christman Constr. Co., Room 302, Union Trust Bldg., South Bend. Estimated cost $500,000. Equipment detail not reported. Noted Jan. 23.

Md., Baltimore — The Mayor and City Council, City Hall, awarded the contract for the construction of a 4 story, 87 x 237 ft. high school (project No. 4) on 36th St. west of Falls Rd., to C. L. Stockhausen Co., Gay and Water Sts. Estimated cost $534,937. Contractor will purchase steam heating and ventilating systems.

Mass., Boston — The Washington-Essex Real Estate Trust, c/o G. A. and R. G. Carpenter, 59 Temple Pl., awarded the contract for the construction of an 8 story office building on Washington, Essex and Harrison Sts., to the G. B. H. Macomber Co., 44 Bromfield St., Boston. Estimated cost $750,000. Steam heating and ventilating systems will be installed.

Mass., Dorchester (Boston P. O.)—The city of Boston awarded the contract for the construction of a high school on Dunbar Ave., here, to the J. Slotnik Co., 448 Bway., Chelsea (Boston P. O.) Estimated cost $1,000,000. Equipment detail not reported. Noted Nov. 28.

Mo., Osage—J. M. Hays Grain Products Co., awarded the general contract for the construction of a 100 bbl. flour mill and 25 bbl. corn mill, also power house to The Monolith Builders, 509 Mutual Bldg., Kansas City, Mo. Estimated cost $100,000.

Neb., Omaha—The Meyer Realty Co., c/o C. B. Kraus Co., 616 Keeline Co., awarded the contract for the construction of an 8 story apartment building to contain 36 apartments, on 38th St. between Dewey Ave. and Harney St. to the Fleisher Constr. Co., 606 Builders Exch., Minneapolis, Minn. Equipment detail not reported.

Ohio, Cincinnati—The Vernon Manor Co., 16 East 7th St., awarded the contract for the construction of a 7 story, 140 x 208 ft. apartment building on Burnett St. and Oak Ave. to the Ferro Concrete Constr. Co., 3rd and Elm Sts. Estimated cost $1,250,000. Equipment detail not reported. Noted Oct. 3.

Ohio, Cleveland—The Cleveland Electric Illuminating Co., C. L. Stone, Asst. Genl. Mgr., Illuminating Bldg., awarded the contract for the construction of piles and substructure of the electric service building at the foot of East 70 St., to The Great Lakes Dredge & Docks Co., Williamson Bldg. Estimated cost $300,000. E. J. Cook, Illuminating Bldg., Archt. & Engr.

Pa., Hazleton—The Altamount Hotel Co. awarded the contract for the construction of an 8 story, 92 x 144 hotel to Wark & Co., 231 South Broad St., Phila. Estimated cost $500,000. Steam heating system will be installed.

Wis., Milwaukee — The Grand & Sixth Bldg., Inc., 425 East Water St., awarded the contract for the construction of the superstructure of an 8 story, 150 x 205 ft. theater and office building on Grand Ave. and 6th St. to Collins Bros., 1600 Grand Ave., Kansas City, Mo.; steel to the Worden Allen Co., Port Washington Rd., Milwaukee. Estimated cost $1,500,000. Equipment detail not reported. Noted Jan. 9.

Ont., Queenston — The Hydro-Electric Power Comn. of Ontario, University Ave., Toronto, awarded the contract for the construction of two 54,000 kva., 12,000 volt, vertical, 3 phase, 25 cycle, electrical generators with general electric thrust for the hydro-electric power plant, here, to the Canadian General Electric Co., 212 King St., W., Toronto. Estimated cost $1,000,000.